OL. XXIX. — No. 8. AUGUST 1952.

Monthly

Bulletin

of the International

Railway Congress Association

(English Edition)

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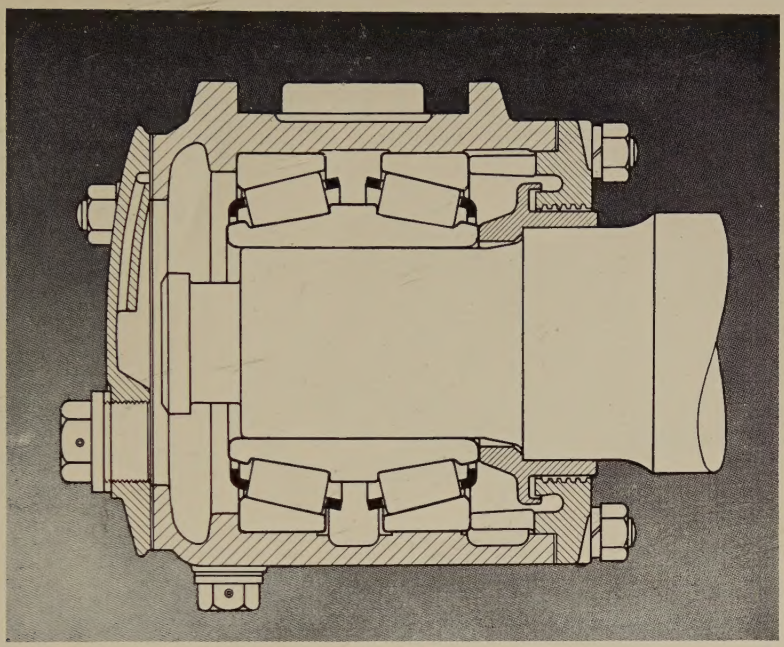

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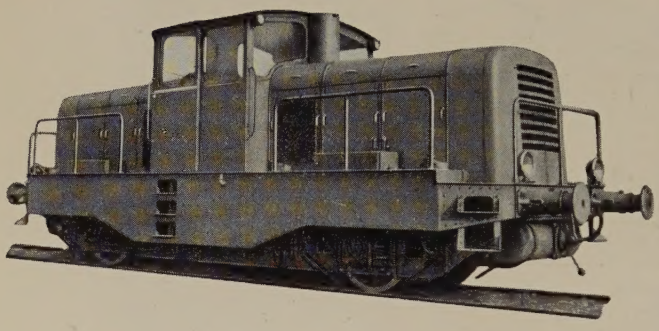

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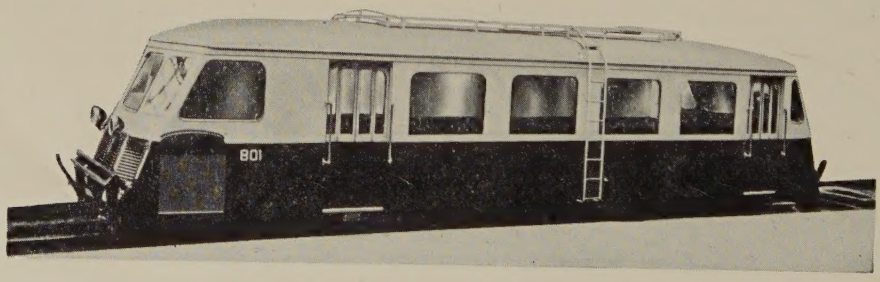

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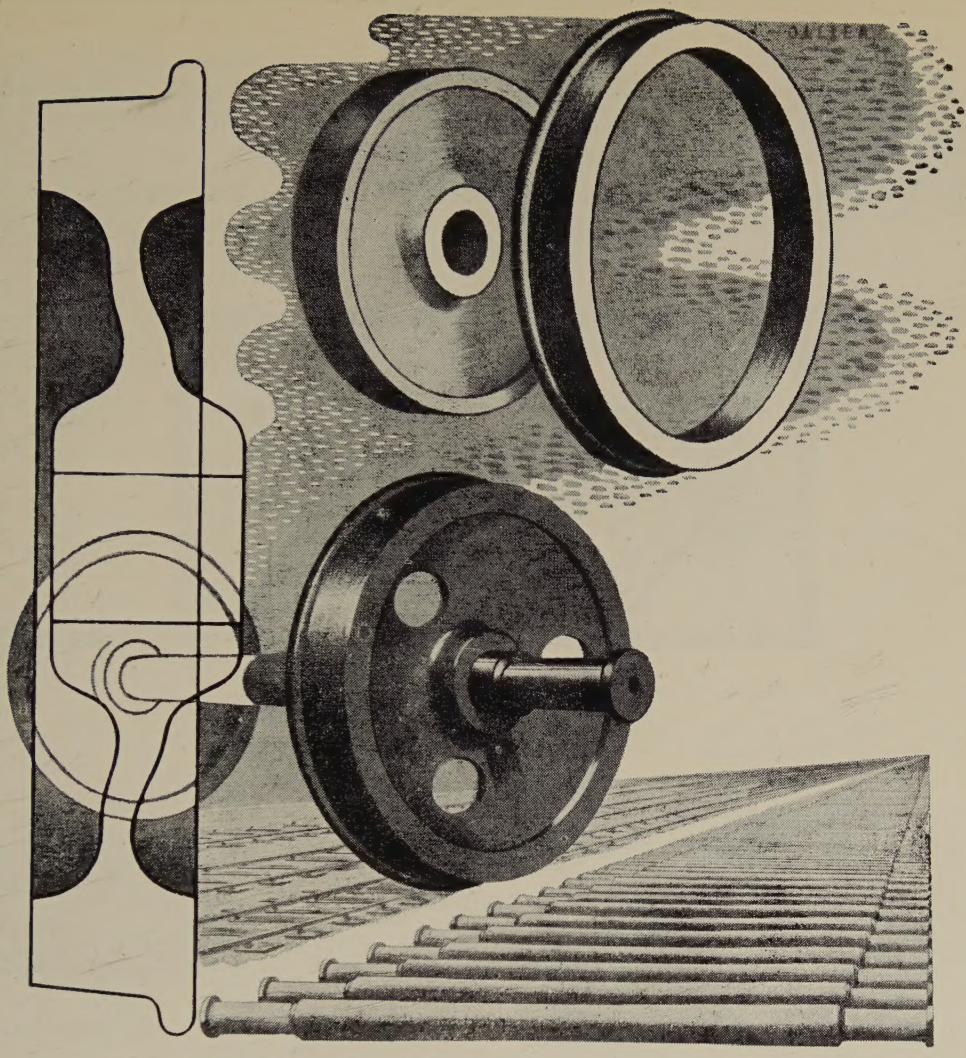

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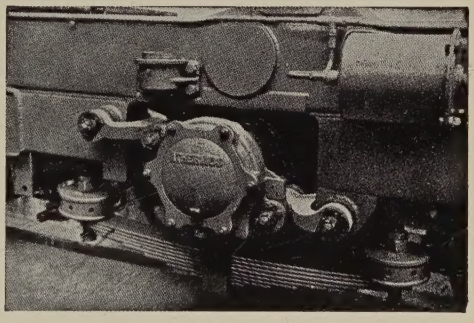

S. N. C. F. electric locomotive C. C. nº 7001 Details of the suspension

Sociétés Générales Isothermos

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60, avenue de la Grande Armée, PARIS (17e)

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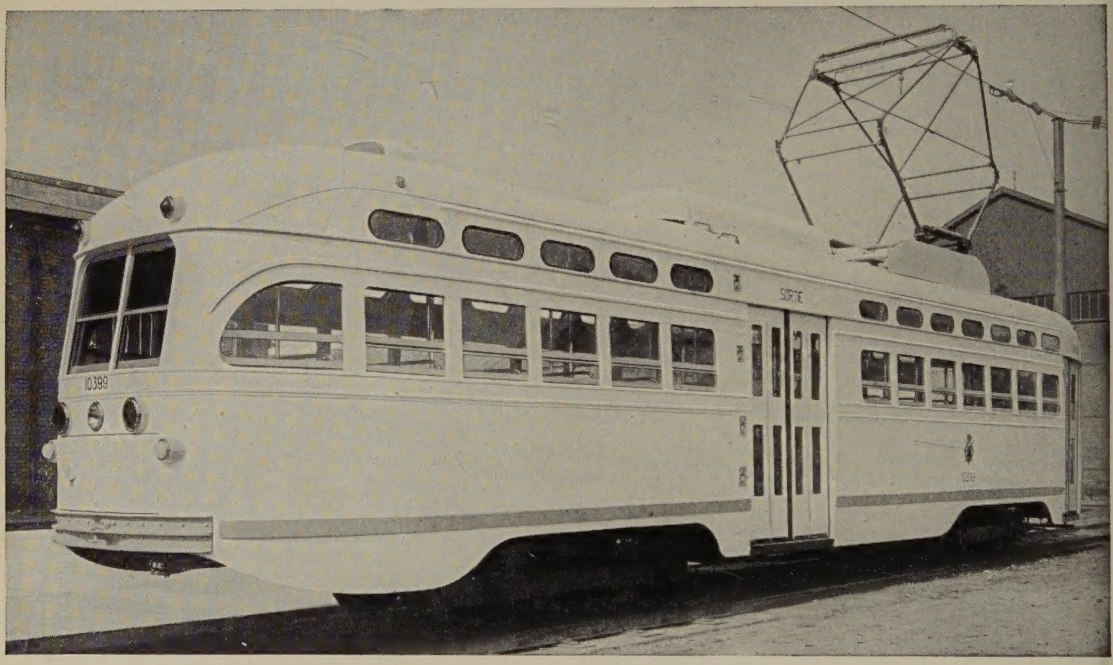

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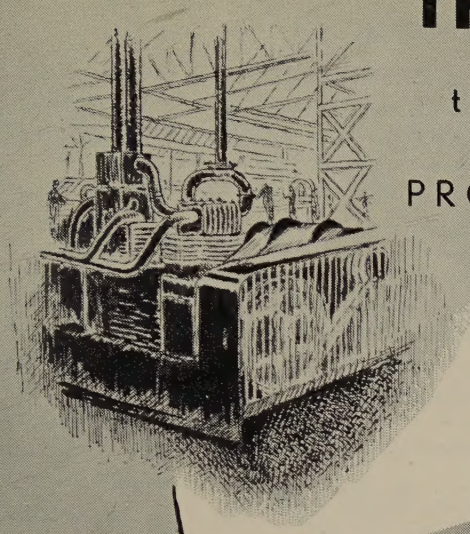

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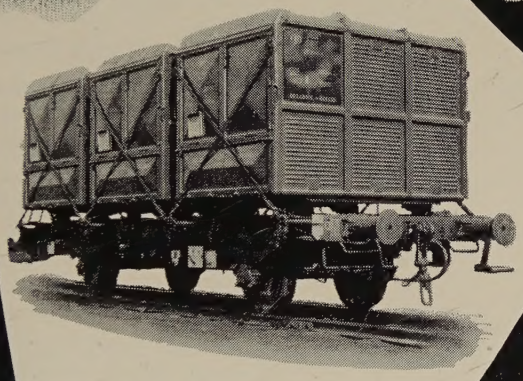

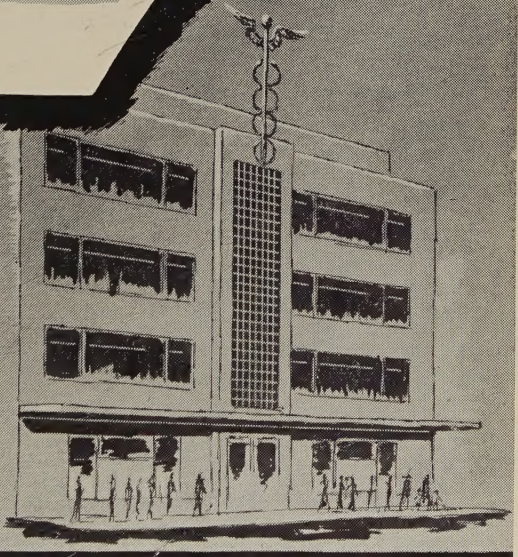

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MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

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Vol. XXIX. — No. 8. August 1952.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621 .135 .2 (44) & 625 .143 .3 (44)]

The new rail lubricator of the French National Railways (S.N.C.F.),

by M. LAFAYE,
Inspecteur Divisionnaire,
and M. VORBURGER,
Inspecteur au Service Technique du Matériel et de la Traction de la Société Nationale des Chemins de fer français.

(Revue Générale des Chemins de fer, May, 1951.*)*

I. GENERAL.

The usefulness of lubricating rails and wheel flanges has been the subject of many articles published in various countries and notably in France in the *Revue Générale des Chemins de Fer* (1). It is well however to remember the seriousness of the rapid wear of tyres by reducing the flanges and of the rails by chamfering the head (2), on lines with sharp curves with unlubricated rails.

Although it was hardly appreciable at the beginnings of the railways, this reciprocal wear progressively grew with the increase in axle loads, rigid wheelbases and, finally, speeds. From observations made in the U. S. A. (3), they grow for the operating conditions given « directly as the area of contact between rails and flanges, and with the degree of curvature of the track, probably inversely as the square of the radii of the curves ». The improvement in the strength of the rails and tyres raised to values now stabilised between 75 and 90 kg/mm² (47.62 t. per sq. in. and 57.14 t. per sq. in.) has not been sufficient to cure it. Had the efforts to prevent wear been kept to this field it would have meant using steel of very high tensile strength (120 kg/mm² = 76.19 t. per sq. in. and above) at a really prohibitive price.

The resort to another method of protection, lubrication consequently, became essential. To confirm this need rather than to consider the consequences of operating on curves under the theoretical aspect, a problem dealt with in several publications, let us make a new contribution to the whole of the observations recorded so far.

This was the position before lubricating the rails on the « Cévennes » line from Clermont-Ferrand to Nîmes and in particular on the section Langeac-Alès on which the most exposed wheels of the locomotives quickly became « sharp » or « straight » and soon reached the minimum allowed (see fig. 1). For example, the guiding pair of wheels, the first pair of coupled wheels and the first pair under the tender of the Mikado locomotive series 2-8-2 E of the Langeac depot had to be withdrawn from service for flanges worn to the limit after

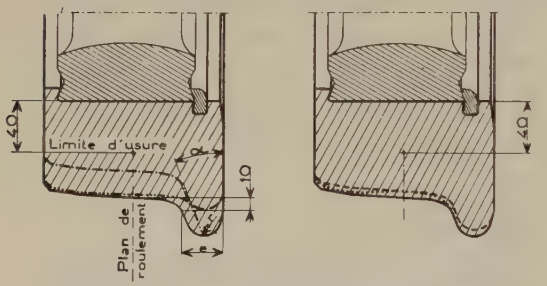
(1) See the *Revue Générale des Chemins de Fer*, April 1885, April 1890, August 1899, November 1927, June 1928, May 1929 and September 1948.

(2) On such curves, the presence of metal flakes collected on the foot of the outer rails demonstrates the gripping that takes place moreover signalled by the characteristic groaning during the passage of each train.

(3) See *Railway Research Service Bulletin* of July 1937.

average distances run of 13 000, 30 000 and 8 000 km (8 077, 18 641 and 4 970 miles) instead of at the lifting distance of 80 000 km (49 709 miles) the minimum for this class.

A tyre of a guiding pair of wheels of a 2-8-2 E locomotive, the flange of which is behaving correctly, can run a distance 15 to 20 times greater than that got from an identical tyre used on the Cévennes line without rail lubrication. This is due to the fact that when taken out of service the original profile of the tyre can be restored by a « cheap cleaning up »



A. — Non lubricated rail. B. — Lubricated rails.
Limite d'usure = minimum thickness.
Plan de roulement = rolling circle.

Fig. 1. — Comparison of the results as to tyre wear with and without lubricated rails. Results from the Cévennes line. 282 E locomotives, guiding pair of wheels.

——— Profile of new tyre (flange thickness, e = 32.5 mm).
—·..·—·..·— Worn tyre after 12 to 14 000 km (7 450 to 8.700 miles) run before lubricating the rails (e = 23; angle $\alpha \leqslant 14°$; radius $r \leqslant 8$).
– – – – – Tyre profile after 80 000 km run on lubricated rails.
—·—·— Profile of tyre after returning used on non lubricated rails.
---------- Economical skimming up of tyre used on lubricated rails.

with the removal of very little metal and in the other at the cost of a serious loss of metal. Frequently too, reprofiling a tyre with a thin flange is impossible, as after returning the tyre would be too thin to be left in service.

When a locomotive tyre flange has thin flanges, the repercussions are aggravated. It then become necessary :

— either to retyre and sacrifice as pure loss a certain thickness of the new tyres to bring them down to a suitable running diameter;

— or re-turn the whole wheel set of tyres to bring them to the same diameter.

The chamfering of the rails follows a similar process. Figure 2 is a section through a rail removed in 1949 from the main lines on the most hilly part of the Cévennes line before the introduction of lubrication and brings out a case of accelerated wear of the head of the rail.

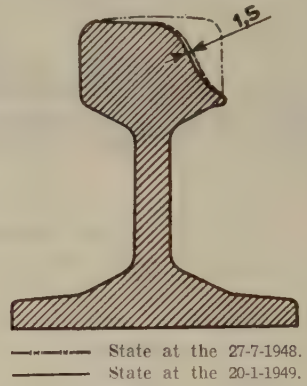


Fig. 2. — Worn condition of a rail on curve, not lubricated, taken up in 1949 from the main lines of the Cévennes line, rail P. L. M. type 48 kg (106 lbs.).

These two actual examples illustrate the excessive loss of steel due to running over non lubricated curves, a loss which outside France inspired recently a detailed article published in No. 5 of 1949 of the review *Nordisk Järnbanetidskrift,* which stressed the importance given in Sweden to the question of rail lubricators.

II. DIFFERENT TYPES OF LUBRICATORS.

1) CLASSIFICATION.

The known devices can be divided into 4 groups :

— the *hand operated lubricators* carried on trolleys using brushes or shoes. These are mainly used in Germany and Sweden.

There is also the direct lubrication by brush still used on important sections of Colonial and even European lines for oiling the flanges of the wheels of certain electric stock in the depots;

— *flange lubricators* fitted in most

European countries (Germany, Spain, Italy, Sweden, Switzerland) to the locomotives, but in the U. S. A. to either the locomotives or the rolling stock and which distributes the lubricant over the wheel flanges. Some feed permanently and some — less numerous — only on curves;

— *fixed curve lubricators* used especially in Great Britain, the Commonwealth countries and the U. S. A. and which are located near the entry to the curves to be lubricated. These dispense automatically when the wheels of the train pass a small quantity of grease (sometimes of oil) picked up by the flanges;

— *rail lubricators carried* almost only by the locomotives, which act automatically by projecting pulverised oil on the upper inner radius of the outer rails on curves to be lubricated, over the full length thereof. They are used especially in France where the P. O. railway fitted the first set of equipment in 1927.

2) ADVANTAGES AND DRAWBACKS.

All the devices mentioned can give savings but from the already long experience of the S. N. C. F. — an experience renewed in recent time with more recent equipment — most do not give the desired results or are only suitable for particular cases.

Hand operated lubricators are simple and cheap. This method however *is extravagant* in staff and lubricant. Moreover the application by brush can be *dangerous* by its lack of precision; defects in the electric signal circuits and slipping many accompanied by damage to the motors are frequently attributed to it.

Flange lubricators protect reasonably well the wheels to which they are applied. Their *efficiency* as regards the rest of the wheels is lower. Consequently, the protection of the rails is *inadequate*. In view of the number of lubricators working all the time, a very small feed is essential, to avoid on the straight sections getting too much lubricant on the tyres. The thin film of oil which then forms on the flanges disperses itself quickly on the curve until it disappears through the pressure of the wheel on the rail. Part of the curve is then run over dry.

The fixed curve lubricators are *effective* and can be recommended for *individual curves* near stations and signal boxes. As each lubricator only protects a restricted length of track, they are not very suitable for whole lines with many curves. The *multiplicity of appliances* that have to be fitted (200 to 300 when 10 to 15 rail lubricators are sufficient to give better results) would represent a *very serious capital investment*. Moreover, from U. S. A. results the annual costs of working a fixed lubricator are of a same order as the first costs.

The *rail lubricators*, more efficacious than fixed lubricators, are to be *preferred* to them, particularly for the open road as they lubricate readily and indifferently all the curves to be lubricated wherever they may be. *Several hundred of pairs of wheels benefit from the film of lubricant deposed by a single appliance.* The cost of one set of equipment is three to four times that of one curve lubricator but the annual cost of up-keep is only 10 % of the value of the new lubricator.

III. NEED FOR AND AIM OF THE MOST RECENT RESEARCHES.

If the principle of lubrication brought out by the « P. O. rail lubricator » tended towards a rational technique, the simplicity of the parts used gave rise to criticism and improvements became essential.

The P. O. fittings were adopted, and rightly, because they were much better than the other types of lubricators but their arrangement designed to suit curves of 150 to 400 m had 3 essential defects :

— delay in starting to feed which deprived the entry to the curves of lubricant;

— lack of accuracy and sensitivity of the three way distributor valve, which furthermore could not be applied to curves exceeding 400 m radius;

— permanent lack of security of the ejection nozzles, very often damaged or torn away

with the risk of lubricating the running surface of the rails not excluded.

An article appeared in the September 1948 number of the *Revue Générale des Chemins de Fer* giving particulars of the steps to be taken to overcome these defects, namely :

— lubricators with pendulum drive for 500 m curves for electric locomotives;

— flexible or telescopic ejection nozzles.

In spite of these modifications, the existing lubricators each of which had been designed for a particular application were still not free from defects. Furthermore, the first results of the appliance described in the present article had shown :

— except in special cases, the pendulum distribution should be reserved to such locomotives on which a driving gear using the movements between parts of the frame or moving parts cannot be devised, the pendulum being moreover inapplicable in particular cases;

— flexible or telescopic nozzles were not used.

An investigation carried out in 1947 by the Rolling Stock and Traction Department of the S. N. C. F. lead to :

1) the creation of quick acting appliances;

2) the provision of an adjustable distribution that will remain set and accurate and also sensitive to curves of all radii up to 800 and even 1 000 m;

3) the development of a fixed ejector practically immune from damage.

The enquiry also showed it was desirable :

— to obtain, in all climates, different discharge rates;

— to have an automatic cut off when the locomotive stopped or automatic variability in terms of the speed;

— to provide appliances that were robust and could not get out of order so as to remove any need for attention by the user.

This investigation lead to the design of a standardized fitting the *Lubrovia* (1) lubricator applicable to all railway rolling stock; steam locomotive with or without compressed air, electric locomotives and railcars and if required various other vehicles.

(1) The S. N. C. F. *Lubrovia* fittings are patented.

The « Société de Robinetterie S. A. J. » hold the licence for these fittings in France, the French Union and Foreign countries.

IV. THE S.N.C.F. LUBROVIA RAIL LUBRICATOR.

1) BASIC CHARACTERISTICS.

The three essential qualities quoted above have been obtained as follows :

a) *Low inertia when coming into action :*

— by having *rapid opening distributors* of the separate oil and air (or steam) circuits;

— by reducing the length of the piping leading to these parts;

— by fitting the *pulverizers* as *near the rails as possible*, the *oil pipes* being always *kept full* of oil by means of valves;

b) *Distribution that remains set and accurate :*

— by applying to the distributors a *cam drive* (in certain cases plungers also have given satisfaction) sensitive to the effect of running through the curve, easy to regulate, and preventing any irregular movement;

— by acting on the distributors through a mechanical or electrical *relay* giving full opening for each time they are acted upon even slightly and with a delayed closing.

c) *Nozzles immune from damage :*

— by making their size across the track as small as possible and fitting them in such a way as to prevent any contact with the rails and check rails.

2) PRINCIPLES OF WORKING AND DESCRIPTIONS.

Figure 3 shows the principle of working in diagrams.

The lubricating oil is contained in a tank, which may be put either at atmospheric pressure or under pressure by compressed air.

So that the lubricator could be applied to all rolling stock running over lines on which lubrication would be justified, *two distinct*

methods of conveying the oil to the point of ejection had to be developed, consisting of :

— *the first,* with the reservoir at atmospheric pressure, *using the single phenonemon of aspiration of the spray nozzle to ensure the flow of oil;*

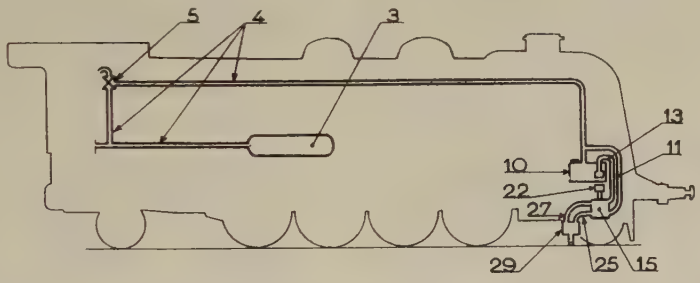
— *the second,* completing the aspiration of the spray nozzle *by forcing the oil to flow under pressure* by connecting the compressed air to the reservoir.

In both cases non return valves keep the pipes full of oil.

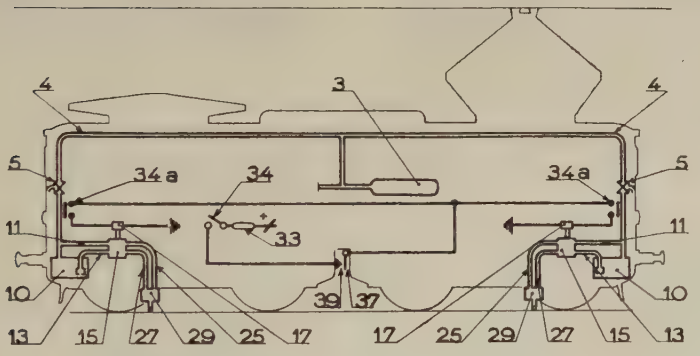
When running through curves of small radius the oil is admitted automatically at the same time as the motive fluid (air or steam) by a distributor to the spray nozzle placed near the outer rail of the curve. The pulverized lubricant is projected on to the upper inner rounded edge of this rail.

There are two units of distributor and spray nozzle per lubricator arranged symmetrically relatively to the track, one for each line of rail.

The opening and closing of the oil pipes and air pipes (or steam) is normally got in each distributor by the action of an oscillating cam operating a link as a result



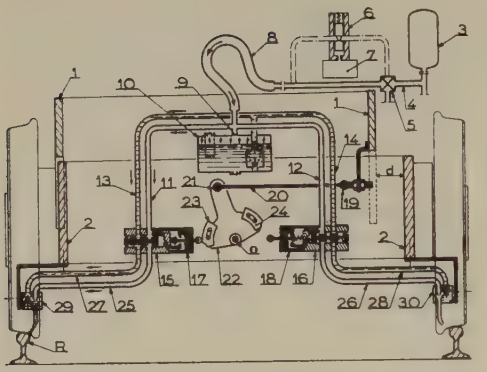
A. — Lubricator applicable to all locomotives.



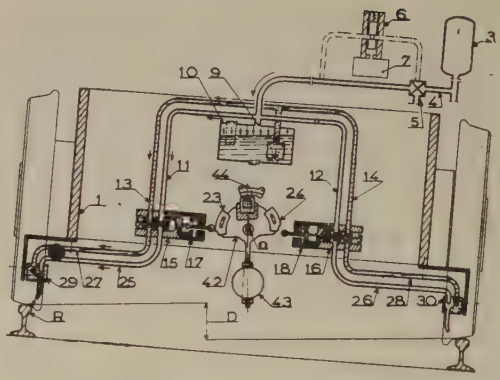
B. — Lubricator applicable to low voltage electric locomotives.

Fig. 3. — Diagram of the principle of working.

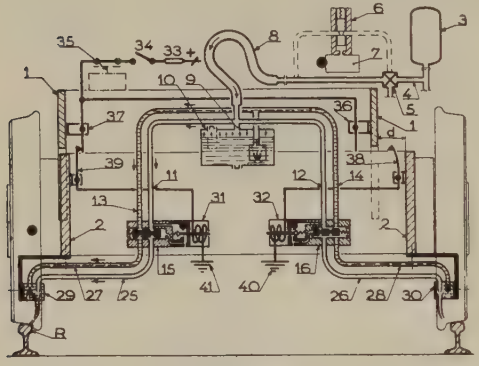
3 — Main air reservoir of the locomotive.
4 — Power air admission pipe.
5 — Shut off valve.
10 — Oil tanks connected to the admission air pipe with outlet oil pipe with a non-return valve to the distributors.
11. — Air pipe to the distributors.
13. — Oil pipe to the distributors.
15. — RM-II (mechanical) or RL-II (electrical) quick action distributor.
17 — Relay of the RL-II distributors.
22 — Cambox of the RM-II distributors
25 — Air pipes connecting the distributors to the spray nozzles.
27 — Oil pipes (always full) between the distributors and the spray nozzles.
29 — Spray nozzles.
33 — Fuse.
34 — Switch.
34*a*— Selectors of the reversing transmitters.
37, 39 — Automatic contact poles.



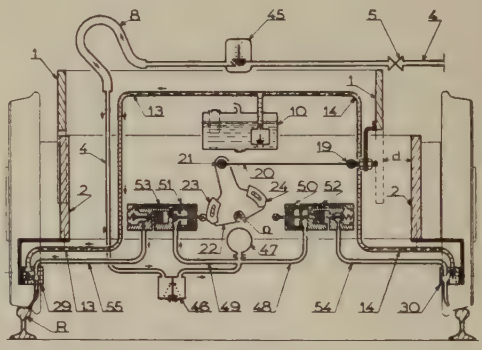
A. — MCR-II arrangement applicable to all locomotives with a secondary frame and having a supply of compressed air, but reserved more especially for steam locomotives.



C. — MPR-II an arrangement often used when A and B cannot be carried out.



B. — LKR-II an arrangement applicable to low voltage electric locomotives and having one (or several) secondary frames.



D. — MCV-I an arrangement for steam locomotives without compressed air: can be modified if need be to use the control used in C.

Fig. 4. — Working diagrams.

1 — Locomotive main frame.
2 — Secondary frame (bogie or truck).
3 — Locomotive main air reservoir.
4 — Incoming air or steam.
5 — Stop valve.
6 — Automatic shut off relay (*a*).
7 — Servo motor operating relay.
8 — Flexible pipe.
9 — Connection between the air pipe and the oil reservoir.
10 — Oil reservoir.
11, 12 — Air pipes.
13, 14 — Oil pipes.
15, 16 — RM-II or RL-II distributors.
17, 18 — RM-II distributors relays.
19 — Fixed point with ball joint.
20 — Driving link.
21 — Ball joint.
22 — Cam shaft with link.
23, 24 — Adjustable cams.
25, 26 — Air pipe.
27, 28 — Oil pipes.
29, 30 — Spray nozzle.
31, 32 — Relays of RL-II distributors.
33 — Fuse.
34 — Switch.
35 — Automatic cut out relay (*a*).
36, 37 — Contacts fitted to frame 1.
38, 39 — Contacts fitted to frame 2.
40, 41 — Earth.
42 — Pendulum cam carrier.
43 — Pendulum weight.
44 — Pendulum brake.
45 — Steam reducing valve.
46 — Automatic steam trap.
47 — Lubricator of the VM-I distributor.
48, 49 — Steampipe.
50, 51 — Relays of the VM distributor.
52, 53 — VM-I distributor.
54, 55 — Steam pipes.

d — Lateral movement of the secondary frame.
R — Outer rail of the rail.
D — Superelevation of the track.

(*a*) Only one of the two relays 6 or 35 can be used at once on the same locomotive lubricator.

of the relative movements of details of the locomotive frame.

On low voltage electric locomotives the distributors can be operated electrically. In this case, contacts are provided operating either by oscillating cams or directly by relative displacements of frame members.

In certain cases, such as locomotives with no mobile frame such as a bogie, the operation by link cannot be arranged.

Several other methods of drive have to be considered.

For example, on the type 030 Diesel electric locomotives to be fitted with a Lubrovia lubricator, the side movement under side control of a driving pair of wheels can be used to control the drive of the distributors.

It may be desirable, in some cases, to use a pendulum acting under the effect either of the super elevation of the track or centrifugal force, according to the speed of running. Such a device varies in sensitivity with the way the locomotive is running and at speeds near those giving equilibrium between the two forces mentioned, it loses all its efficacy.

The pendulum through the unreliability of its movements is not suitable for lubricating sharp curves run over at low speed. In these latter cases it is desirable to use operating gear secured to the track and working lubricators carried on the locomotives.

The spray nozzle is based on the principle of the venturi tube. The ejection nozzle built into the appliance is sufficiently strong in section to stand slight shocks from unexpected obstructions, but yields under heavy blows. Whilst breakage is extremely rare, it is better to have breakage than distortion as the discharge orifice after the accident is then far enough away from the rail for the oil mist which discharges after the parts of the pipe came apart to be dissipated before reaching the running face of the rail and thereby eliminates any risk of slipping.

In addition, provision is made to fit to the oil pipe of the lubricator, an automatic valve suppressing any discharge of oil from the broken pipe until the latter is renewed.

Except in special cases, the spray nozzle is fitted in the direction of running behind the first pair of wheels of the locomotive; this prevents any contact with the pedals and keys of the track. The leading guiding wheels are not adversely affected in any way however as they benefit from previous lubrications, the rail lubricator creating a « state of greasiness » over the whole length of the curves lubricated.

The equipment, if need be, is completed by a relay which automatically shuts off the lubricator whenever the locomotive is stopped. This relay acts :

— either directly on the auxiliary air supply though a servo-motor having a movement which is a function of the running speed : it can then form a mechanism for automatically varying the quantity of oil discharged;

— or on the electric operating circuit usually in the form of a simple contact fitted to the speed recorder.

With electric drives it may be necessary to fit such a relay. This is so in particular for railcars running in multiple units.

3) TYPICAL ERECTION DIAGRAMS AND APPLIANCES.

Figure 4 shows diagrammatically the different layouts actually in use or being applied.

Figures 5 and 6 show in section the distributor with mechanical relay and the spray-nozzle.

In the case of the electric relay distributor, the valve 62 is replaced by an electric valve.

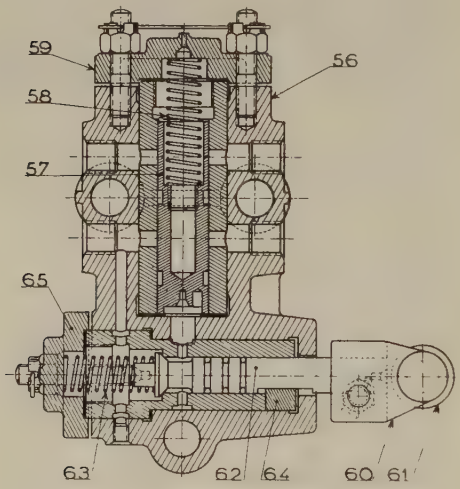
The spray nozzle used when the oil reservoir is open to atmosphere and that which is fed with oil under pressure practically differ only by the calibration of the ejector.

Figure 7 shows the position of the nozzle relatively to the back. The running gear may have a lateral play of 20 mm (25/32″), sometimes even more, without any danger to the nozzles being damaged by super elevated check rails.

Figures 8, 9 and 10 are part views of the assembled lubricator.

4) WORKING OF THE APPLIANCE.

Referring to figure 4, diagram A, the lubricator using oil under pressure is shown in position for lubricating the outer rail on the curve.

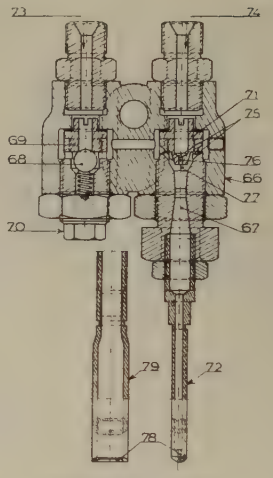


Longitudinal section.

Fig. 5. — RM-II distributor.

56 — Distributor body.
57 — Distributor piston.
58 — Piston spring.
59 — Piston cover.
60 — Head.
61 — Roller.
62 — Valve relay.
63 — Valve spring.
64 — Key guiding the roller.
65 — Valve cover.

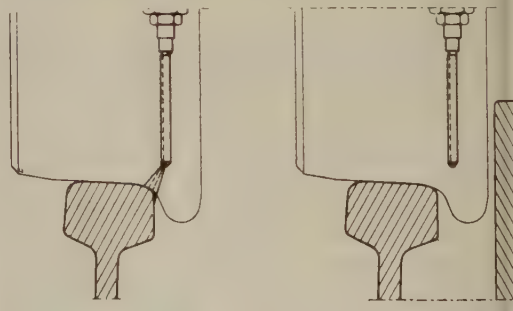
On running into the curve, the secondary frame moving relatively to the main frame causes the cam carrier to rotate as the upper joint of the latter is operated by the control link attached to one of the main frame longitudinal members. The displacement so caused brings the cam corresponding to the part of the lubricator situated on the outer side of the curve against the roller of the distributor, which by the relay causes air to be admitted to the piston of distribution. The latter,



Longitudinal section.

Fig. 6. — Spray nozzle.

66 — Body of spray nozzle.
67 — Convergent divergent cone (venturi tube) of nozzle.
68 — Oil non-return ball valve.
69 — Seat of ball valve.
70 — Plug holding the ball.
71 — Power nozzle.
72 — Ejection nozzle ER-I or 6 (oil reservoir under pressure).
73 — Incoming oil.
74 — Incoming air (or steam).
75 — Calibrated oil delivery jets.
76 — Calibrated power jet.
77 — Suction and pulverisation chamber.
78 — Pulverized oil ejection jet.
79 — ER-II ejection nozzle (reservoir of oil at atmospheric pressure).



A. — On curve whilst lubricating.

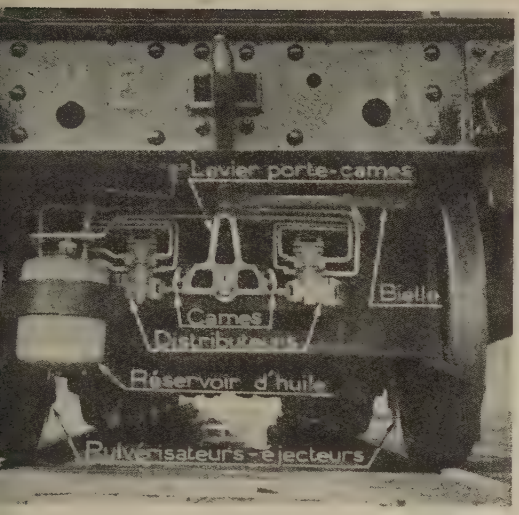
B. — On reverse curve or on the straight.

Fig. 7. — Position of the ejection nozzle relatively to the rails and check rails.

The position of the ejection nozzles is such that:

1° they are sheltered from any contact with the rails or check rails, after making allowance for wear and lateral play of the running gear;

2° the jet of pulverized oil is projected only into the upper inner radius of the rail head.



Front view.

Fig. 8. — Principal parts of the Lubrovia lubricator in position on a steam locomotive front view.

The link connects one longitudinal girder of the main frame to the cam lever which can turn about a pivot on a spindle fastened to the truck frame. On entering a curve, the relative displacement of this latter causes the lever to rotate. If the displacement of the truck is sufficient (the cams are set to assure the lubrication of curves of under 600 m (656 yards radius) the cam placed on the side of the outer rails of the curve act on the corresponding distributor and causes the lubricator to come into action instantaneously. At the end of the curve, the truck returns to its mid position, the cam comes away from the roller of the distributor and the lubrication then stops.

Levier porte-cames = lever carrying the cams. — Bielle = link. — Distributeurs = distributors. — Réservoir d'huile = oil reservoir. — Cames = cams. — Pulvérisateurs-éjecteurs = spray nozzles.

under load on one face by a spring which keeps it in the position in which the feed orifices are shut when the relay itself blocks its air feed, then takes the discharge position under the effect of the thrust exerted by the compressed air on its other face and admits simultaneously by two grooves, oil and air to the spray nozzle. A lift even very slight of the relay valve of the distributor results in the instantaneous full opening of the air and oil discharge orifices.

The air, which passes through the operating nozzle of the sprayer, sets the ejector going, the oil lifts the non-return valve off its seat, and flows immediately (the pipe being always full) into the suction chamber through two calibrated jets. It is pulverized then projected by the spray nozzle on to the area to be lubricated. Owing to the short distance separating the pulverizing chamber from the ejecting nozzle, the oil is in a perfect state of pulverization when it reaches the rail.

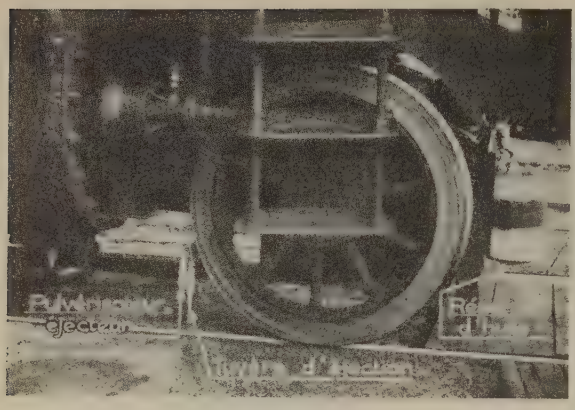
On leaving the curve to be lubricated, the secondary chassis resumes its normal position relatively to the main frame and the cam moves away from the distributor roller. The relay valve falls on to its seat and the gas and air in the admission chamber of the distributor piston is discharged through a leakage orifice. The piston returns ([1]) slowly to its stationary position under the action of the control spring and

([1]) This delayed closing enables the lubricator to operate continuously whilst going through a curve when, at its maximum setting, the pilot relay is caused to open and close a number of times in succession.

General view.

Fig. 9. — Electric locomotive fitted with Lubrovia equipment.

Pulvérisateurs-éjecteurs = spray nozzles. — Réservoir d'huile = oil reservoir. — Distributeur = distributor.



Side view.

Fig. 10. — Lubrovia spray nozzle fitted behind a guiding wheel of a steam locomotive.

The components of the lubricator fitted in front of the truck are partly visible.

Pulvérisateur-éjecteur = spray nozzle. — Tuyère d'éjection = discharge jet. — Réservoir d'huile = oil reservoir.

shuts off the air and oil discharge pipes. The lubricator ceases to discharge as the air under pressure in front of the distributor becomes used up. The lubrication stops usually towards the end of the leaving transition of the curve.

V. CHOICE AND USE OF THE S.N.C.F. LUBROVIA LUBRICATORS.

1) DESIGNS FOR NORMAL APPLICATIONS.

a) The processus of conveying the oil mentioned in the preceding chapter can be applied :

— the first (reservoir at atmospheric pressure) to all locomotives but is most suitable when steam is the motive force (fig. 4, diagram D) as putting oil under pressure directly by steam raises a delicate problem to solve and mechanical pressure is not justified;

— the second (reservoir under pressure) to locomotives with compressed air (fig. 4, diagrams A, B and C);

b) The equipments using compressed air are in principle those of diagrams A or B.

Beside the layout using steam (diagram D) for certain good reasons it may be wished to alter to it some older type sets using compressed air. *The P. O. lubricators are being modified in this way by the S. N. C. F.*

c) An erection diagram of the installation is needed for each class of locomotive. It deals with the determination :

— of the places for the appliances, brackets, and piping;

— of the exact location of the cams and their setting in terms of the way the locomotive to be fitted inscribes itself in the curve, obtained from diagrams got out for different typical curves.

2) RULES GOVERNING THEIR USE.

a) *Quality of oil.*

The new lubricators use all motion oils of standard quality (1).

No provision has been made for preheating.

All that is required in cold weather to maintain a practically constant viscosity is to add according to the ambiant temperature some gas oil or lamp oil as shown in the tables issued for this purpose.

During hot weather, either a heavier oil than usual should be used or the feed of the spray nozzle reduced by simply changing the operating nozzle.

b) *Frequency of lubrication. Quantity discharged.*

Whatever the quality of the oil, a range of nozzles provided with each appliance makes it possible to get a wide variation in the discharges : the diagrams of figure 11

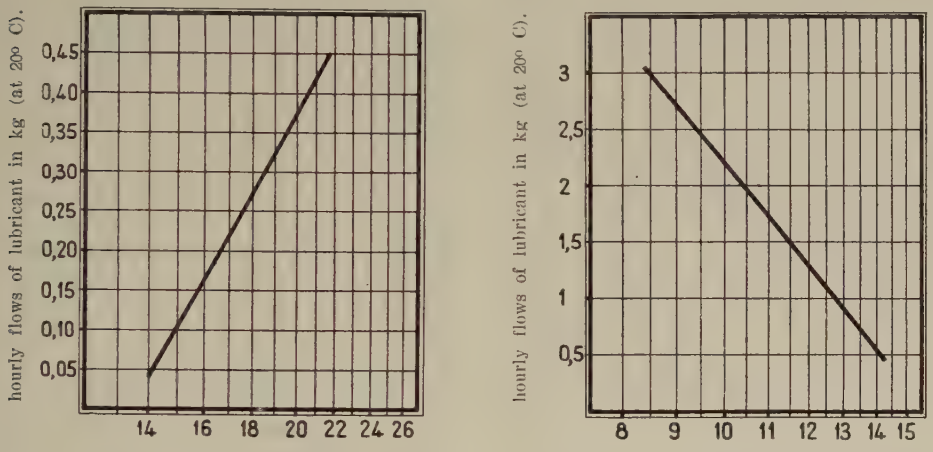
(1) Recovered oil, can be used but it is better to use an oil of known and stable quality in order to be more certain of getting the desired result.

In some cases, it may be worth while to use special oils, graphited for example.

show for two particular cases the possible variations. As the result of the latest observations the recommended practice is to adjust the lubricators to lubricate all curves of less than 600 m (656 yards) radius (a limit which may be 800 m [875 yards] or even 1 000 m [1 093 yards] according to requirements) with an optimum discharge of 40 g (617 grains) per kilometre of oil per rail effectively lubricated. This last value can be temporarily raised without major difficulty to 70 g (1 080 grains) per kilometre when the number of lubricators available is insufficient.

The frequency of lubricating, varying with the traffic density and the climate of the country run through is about once every four trains on the S. N. C. F. mountain lines. In any case it is as well to fix 150 at least and 300 at most (values corresponding to the discharge of 40 g per kilometre of rail lubricated) as the numbers of pairs of wheels which can run over the line between two consecutive lubrications.

The specific *consumption* (number of grammes of oil discharged related both to the kilometre of curve lubricated — not to be confused with the running kilometre of track — and to the unit circulating — the pair of wheels) lies between 0.133 and 0.267. It is very small and *less than of the fixed curve lubricators and of the flange lubricators.*



Sections in mm² of the orifice of the spray nozzle.
A. — Locomotives used at low speed (shunting):
— Oil tank (atmospheric pressure);
— Height of the orifice of the discharge jet above the neck = 13 mm.

Heights in mm of the orifice of the discharge jet of the spray nozzle above the neck.
B. — Locomotives running at average speed or at high speed:
— Oil tank under pressure;
— Section of the orifice of the spray nozzle = 1.77 mm².

Fig. 11. — Curves of the base flows.

Pulverization with compressed air at 5 hpz of motion oil of kinematic viscosity of 700 centistokes at 20° C. Section of the orifice of the spray nozzle: 1.77 mm².

3) EXCEPTIONAL APPLICATIONS.

The new principles can be applied without difficulty to the lubrication of tyre flanges. Actually, although French experience shows that flange lubricators are not a complete solution for the open lines, it may be that they solve the isolated and special case of certain shunting locomotives for example. The spray lubricator is better than the contact lubricator with which there is a risk of it becoming covered with greasy dirt or mud.

VI. RESULTS OBTAINED AT LANGEAC RUNNING SHED WITH S.N.C.F. LUBROVIA LUBRICATORS.

1) QUALITY OF THE LUBRICATION.

The projection of the oil, the pulverization of which has been found to be excellent limits itself to the upper inner radius of the rail head. *No tendency to wheel slip attributable to the lubrication has been observed,* and this in spite of many grades of up to 2.6 %.

This point which had been the unexpected obstacle against which many of the older appliances were wrecked themselves, and which had encouraged all doubts as to possible success, was the object of a very detailed investigation.

During inspections of the track immediately after lubrication, no trace of oil was ever found on the table of the rail nor on the rail foot (1).

2) RESULTING ECONOMIES.

a) *Locomotives.*

— *Tyres.* — *Removing wheels* between the periodic lifts of the 282 E locomotives at the Langeac depot to turn up the tyres *has now been stopped.*

The savings in tyres, of the maintenance work, and the saving by reducing the number of times engines are immobilised are considerable.

— *Energy.* — The comparison of the return of consumptions of fuel at the Langeac depot after taking into account the factors of fluctuation common to the S. N. C. F. as a whole during the periods selected, and also of the loads hauled, showed a *reduction of 10 % in the consumption per kilometre.* This result is not surprising as it is very evident that the rolling resistance of the trains over the lubricated lines is very appreciably reduced (1).

b) *Rolling stock hauled.*

The use of the stock belonging to the Cévennes line has prevented any precise statement of the results obtained being given. However, in this field too the improvement in the tyres must be substantial (2).

c) *Track.*

The savings in *rails* and with them the sleepers are great, as the rail profils taken several months after the lubrication was begun did not reveal *any appreciable wear,* where before it often exceeded a millimetre in three months.

The familiar grinding noise due to the tyres gripping the rails has gone.

It is now possible to envisage a normal length of life of rails on curves and to complete, without additional labour, the usual maintenance work as the renewals of rails as a result of the chamfering of the inner radius will be avoided.

3) BEHAVIOUR IN SERVICE, AND MAINTENANCE OF THE APPLIANCES.

The *costs of repairs* are negligible. Once regulated, the links, cams, and distributors,

(1) Along with this recent test, it is not without value to point out that the lubrication of the rails has no influence on the number of cases of wheel slip as has been proved and in particular on the S. N. C. F. standard gauge lines on curves on up grades of 3.3, 4, and even 4.3 % and on the Cerdagne line of 1 m gauge where the gradients are as great as 6 %.

(1) Previous observations during locomotive trials without lubrication of the rails had already revealed wide variations in the energy used solely due to changes in the hygrometric condition of the air.

(2) To illustrate the saving let us refer to the tyres of the carriages making up the Laqueuille-Le Mont Dore rake, which before lubricating the rails, had to have the tyres turned up after 3 months service in the Summer but since the rails were lubricated and after the same service, the flanges are still of the standard thickness.

require no attention, other than at the periodic operations of lifting the locomotive to which these are fitted. At the first lift, after running 80 000 to 100 000 km on the average, all that is required is to check the play in the joint of the cam carrier lever, the other parts requiring no attention until after several lifts (this lever is to be fitted with roller bearings).

To get the precision lubrication reported above, it is essential the position of the spray nozzles be set very accurately but this setting, readily done, needs only be reset after 3 or 4 months. Current attention consists simply in filling the oil reservoir and in a quick inspection each visit to the running shed.

Finally, the perfect way in which the fixed ejection nozzles behave, and the precision of the pulverisation make it unnecessary to use flexible or telescopic nozzles.

4) VARIOUS EFFECTS RESULTING FROM THE LUBRICATION.

A notable improvement in the condition of the locomotives and vehicles has been seen on the lubricated lines.

The entry into the curves is much smoother, the trains move more easily and the risks of derailment less on lines benefiting from lubrication from the fact of the generalised greasy state of the zones of contact between the rails and flanges.

The safety of running is increased and in certain cases an increase in the maximum speed on curves could well be considered.

Moreover, in spite of what might be expected the lubrication affects favourably the tractive efforts that can be developed on curves when starting and at low running speeds.

In fact, for each pair of wheels, on a curve there is a slip of one of the wheels on the rail due to the difference in the rolling circles and practically inevitable in spite of the coning of the tyres. The result is a reduction of adhesion with a consecutive diminution of the maximum efforts transmissible. Without lubrication, the friction of the flanges against the outer rails on curves then tends to cause a partial slipping of the inside wheels; with lubrication on the contrary, this latter affects rather the outside wheels the load on which is reduced through the superelevation, which, by a better use of the adhesion, increases the possibilities of traction.

Recent experience has not enabled values to be given these advantages : it corroborates however observations already made. As an example, if in France it has been noted that the maximum tractive efforts, without slip, obtained on curves with dry rails developed by certain electric locomotive reach not more than 75 % of those on the straight, in the U. S. A. measurements have shown that on sharp curves when lubricated the tonnage hauled by a locomotive can be increased by 15 to 20 %.

5) OVERALL BALANCE SHEET.

The effects of the lubrication of the rails can be summarised by stating that from the double point of view of the wear of the wheel flanges and rails on the one hand, and the consumption of motive power on the other, lubricating the rails has rendered the running conditions over lines with small radius curves very much the same as those on ordinary lines (1).

The new experiment shows that in critical cases, the lubrication should at least *quadruple* the life of the *rails* and *quintuple the mileage* between returning tyres. (It should be noted that the total distances made by locomotive tyres on rails lubricated or dry are in the ratio of 15 to 1 on the average.) A rough balance sheet for the working shows a *net monthly saving* of over 2 million francs for the Cévennes line between Langeac and Alès (2). In one month, in such circumstances, the total cost of the equipment of a depot (10 locomotives at Langeac) is entirely recovered.

VII. CONCLUSION.

As this review clearly brings out, the need to lubricate the zone of contact of

(1) According to the *Railway Gazette*, No. 23, June 1938, these results have been confirmed by those obtained in Australia.

(2) Single line 150 km long, average traffic with many 250 to 500 m curves.

flange-rail on small radius curves has been felt for a long time and the experience of the S. N. C. F. has shown *that the appliances which lubricate directly the rails the whole length of the curve are the best.*

Those just described solve the problem as a whole, the proof having been given that they satisfy the objective :

— perfect lubrication of the rubbing zone of the flange-rail *without any risk of lubricating the rolling face of the rail;*

— complete protection of the wheel flanges and the part of the rail subjected to chamfering;

— minimum costs of maintenance and of supervision of the appliance.

Furthermore the savings realised exceeded those expected.

The use of these rail lubricators is now being made general over the whole of the S. N. C. F. and in particular the 2-8-2-R locomotives used on the Mediterranean coast line : Marseilles-Nice, are being fitted.

Finally, the old appliances are being altered in accordance with the new designs.

[621 .392 & 624]

Accidents to some welded bridges under very low temperature conditions.

The *Génie Civil* of the 15th June, 1951, has dealt with the failure of the Duplessis welded road bridge over the Saint-Maurice river at Quebec (Canada).

The main points are summarised below.

This bridge, one of the largest road bridges in the Quebec province failed on the 31st January, 1951, at 3 a.m., when the temperature had fallen to — 34° C.

This very low temperature could not but have exercised a harmful effect on the strength of the welds even though according to a Highway Research Board's report, certain fractures noted in February 1950, that is over 2 years after the bridge was built, were due solely to the metal not being of good enough quality.

Analysis had shown gas inclusions as well as local concentration of carbon as high as 0.4 % and of sulphur up to 0.116 %. The girders which had shown defects had been repaired.

About a fortnight before the accident on the 31st January, 1951, the bridge was inspected thoroughly without any apparent defect being observed.

The author of the study asks the question, could the rollers of the bearings have become ice bound and thereby the free movement in length due to temperature changes been prevented ?

The cause of fracture of the main girders has not yet been ascertained.

This accident was examined by Mr. F. S. Merritt in the *Engineering News Record* of the 8th February, 1951.

We feel it may be useful to summarise briefly the characteristics of the bridge, the design of which moreover was straightforward, and to refer again to some accidents of the same type, which have occurred within the last fifteen years.

The structure is divided into two sections separated by the St. Christopher Island.

It consists of two *continuous* plate girders set at 9.45 m (31′) centres connected by cross stretchers spaced 3 m (9′ 10 1/8″) apart.

The western section 420.60 m (1 380′ 9″) long consists of eight spans, six being 54.86 m (179′ 11 7/8″) long and two 45.72 m (150′ 1/8″), four of which collapsed.

It is carried on the two abutments and seven piers in concrete, the centre pier having fixed bearings and the others roller bearings.

The lower flange of the main girders is parabolic, the upper flange is straight, the height in line with the bearings is 3.65 m (11′ 11 6/8″) and 2.44 m (8′ 1/16″) at the middle of the 54.86 m span.

The thickness of the web is 10 mm (3/8″), the web having a stiffener in the *inner face* every 1.5 m (4′ 11 1/16″).

The floor 15.55 m (51′ 3/16″) wide carries a roadway 12.55 m (41′ 2 3/16″) wide and two footpaths cantilevered out 1.50 m, the welded cantilevers being 3 m (9′ 10 1/8″) long.

The floor is formed by a reinforced concret slab, the thickness of which varies but slightly. In line with the bearings, the web of the main girders is *reinforced by the welded plates* required by the loading.

The bed of the river is fine sand on a layer of clay.

The piers are 12 m to 16.75 m (39′ 4 1/2″ to 54′ 11 1/2″) high.

We have no information about the kind of foundation nor of the mechanical characteristics (angle of internal friction, cohesion, etc.) of the two formations, sand and clay, factors which can affect the continuity of the main girders.

The reader will find in the *Génie Civil* further information and in particular on the loadings.

The erection took place in the good weather season of 1947.

The collapse took place suddenly.

It should be noted that the cracks found in 1950 started in the top part of the flange of one main girder at about 3.5 m (11′ 5 13/16″) from one pier just where a 60 mm (2 3/8″) thick plate had been welded to a piece 50 mm (1 31/32″) thick in a region under tension.

As is known, the attachment of a flat of such thickness is a delicate operation, the effect of which it is endeavoured to reduce by progressively reducing the thickness on a slope of at most 1 in 10.

Generally, the craters at the end of the iron filet are avoided by extending the filets beyond both ends by short lengths of plate to form small troughs, which are removed after the weld has been completed.

In Belgium, two welded Vierendeel bridges, one the Herenthals-Olen, over the Albert Canal; the other the Kaulille over the junction Canal, in Campine, were closed in January, 1940, owing to serious defects occurring during a period of abnormally cold weather with atmospheric temperatures of the order of — 20° C.

The fractures as on the Duplessis bridge were sudden, with violent detonations.

Characteristics features of these bridges.

Herenthals-Olen bridge.

Built 1936-37, failed 19th January 1940, central bay of 61 m (200′ 1 5/8″) span, Vierendeel side girders with parabolic upper flange and straight lower flange : I section fabricated by welding, floor plating with two transversal expansion joints, clear cuts through the reinforced concrete bed.

Kaulille bridge.

Built in 1934-35, failed 25th January 1940, single span of 48.75 m (159′ 11 1/4″), Vierendeel side girders with parabolic upper flange, straight lower flange : Grey section, plating having two transverse expansion joints with clear cut through reinforced concrete bed.

These joints, ordered by the Military Engineers to help destruction in case of war resulted in a sudden drop in the moment of inertia of the lower flange and appear to have had an unfavourable effect on the proper behaviour of the structures.

The general opinion is that the exceptional cold making the steel more brittle is the fundamental cause of the defects that arose : cracks and failures in the lower flanges.

It should be noted that certain rolled sections of the flanges may also have had internal stresses set up during rolling and the subsequent welding could have aggravated this condition dangerously.

As a matter of fact, as Mr. PORTEVIN has made clear, the three operations involved in a weld namely : casting, metallurgy and heat treatment, take place almost instantaneously, whereas in ordinary metallurgical practice they are carried out separately and under the optimum conditions for each.

The physical-chemical laws governing this operation during welding are imperfectly known and should incourage prudence and the greatest care.

In the case of alloys, the metallurgists teach us that the structural phenomena of cristallisation during a welding can complicate themselves by changes of phase.

In this case, we may also remember the defects that occurred in Germany on two welded St 52 steel bridges.

The two rail bridges of the Zoo station, in Berlin, consisting of two 50 m (164′ 1/2″) long spans, one single track, the other double, a short time after completion and going into use, showed cracks in the lower flanges of the girders.

According to Dr. G. Schaper, these defects could be attributed to the too high proportion of alloy in the steel, the chemical composition of which caused excessive hardening when welding the heavy flats and cracking under contraction stresses.

The German Railways substituted these two bridges by two rivetted bridges.

In the case of the great Rüdersdorf viaduct, two different main girders, suddenly, cracked at the same place during a drop of temperature (— 10°) also with a violent detonation. Here again, like the Zoo bridge, the fracture, according to the enquiry, started in the lower flanges of the main girders.

As a result of these accidents, the German steelmakers have been forced to improve the chemical composition of St 52 steel, in particular to get a fine grain.

These accidents to welded bridges and structures show that they are very sensitive to falls of temperature below zero degree C: rivetted assemblies stand up better, no doubt due to greater flexibility in adapting themselves to the conditions.

In the case of welding, what is the cause of these disappointments ? It would appear to be due to the complexity of the phenomena still ill defined, which accompany it.

What is one of the principal remedies known to-day ? We believe the ductibility of the steel. This permits the secondary stresses and overloads to be levelled off by the plasticity of the metal and assures uniform distribution of the stresses along the filets.

These disappointments are the reckoning to be paid when each new process is introduced. A code of good practice will result from enlightenment obtained by the behaviour of the existing structures.

Welding technique has not ceased to advance during the last fifteen years, thanks to laboratory investigations and acquiring experience; it is called in our view in spite of a few cases of lack of success to a great future even on bridges and especially structures.

BIBLIOGRAPHY.

Génie Civil (15th June 1951) : « The failure of the Duplessis bridge over the Saint-Maurice river, at Quebec (Canada). » .

Ossature Métallique (Feb. 1940) : « Failures of the bridges over the Albert Canal. »

Ossature Métallique (April 1940) : « The welding of bridges and structural works », by G. Schaper.

J. Dubus.

[625 .25]

New driver's brake valves and distributors for modern locomotives and motor coaches,

by S. Keller,

Engineer-Director of the Brake Department of the firm Bühre & Co, Oerlikon.

The brake gear on modern locomotives for working both goods trains and also passenger trains and expresses is quite complicated if the present ordinary compressed air equipment be used. Above all, many pipes for connecting the many pressure reducing valves, distributors and relays, branched either in parallel or in cascade are needed.

As the mechanical, electrical, and pneumatic appliances as well as the electrical wiring and the needed piping are usually confined in the very limited space on the locomotive, the undoing of a connection to change any compressed air detail is usually difficult and takes much time.

The new Oerlikon compressed air brake fittings for locomotives and railcars meet modern needs. Not only the driver's valves for the automatic and direct brakes but also the distributors and relays have a carrying bracket to which all the mains are connected. As a result every part can be taken down and exchanged without undoing the piping.

Moreover, all the details of one type of pneumatic equipment are interchangeable. As these appliances have no slide valve nor metal piston, they are much simpler and cheaper to repair.

Oerlikon driver's valve, type FV3.

The FV3 type of automatic brake is distinguished in particular by a very sensitive pressure variator, reliable in working and not subject to any wear. As a result of tests made with very long passenger and goods trains, the jerky filling at high pressure and in a short time with the danger of overloading the brake cylinders has been replaced by a slight overloading at low pressure for a longer period. The overload is about 0.4 kg/cm² (5.6 lbs. per sq. in.). When the brake handle is re-set to the running notch, the slight excess pressure will be automatically brought to the service pressure what ever the length of train and without the brakes being applied. The comparative trials carried out on trains of 150 to 200 axles have shown that the time to release the brake is considerably shorter at the end of the train than when the step by step method of application is used. The driver's valve type FV3 makes it possible to take full advantage of a brake with variable release. The design of the valve is such that it can be fitted very nicely to the table in the driver's cab.

Oerlikon driver's valve, type FD1

The FD1 pattern driver's valve for the direct acting brake has neither slide valve nor metal piston. It can be used not only when the engine is shunting but also — thanks to its great capacity — for the direct feed of the brake cylinders of whole trains. The maximum desired brake pressure can be set between very wide limits by adjustable stops. Within these limits the pressure can be increased or reduced by fine gradation. Thanks to its small size and its neat design, this valve also lends itself to being fitted directly on the control table of railcars.

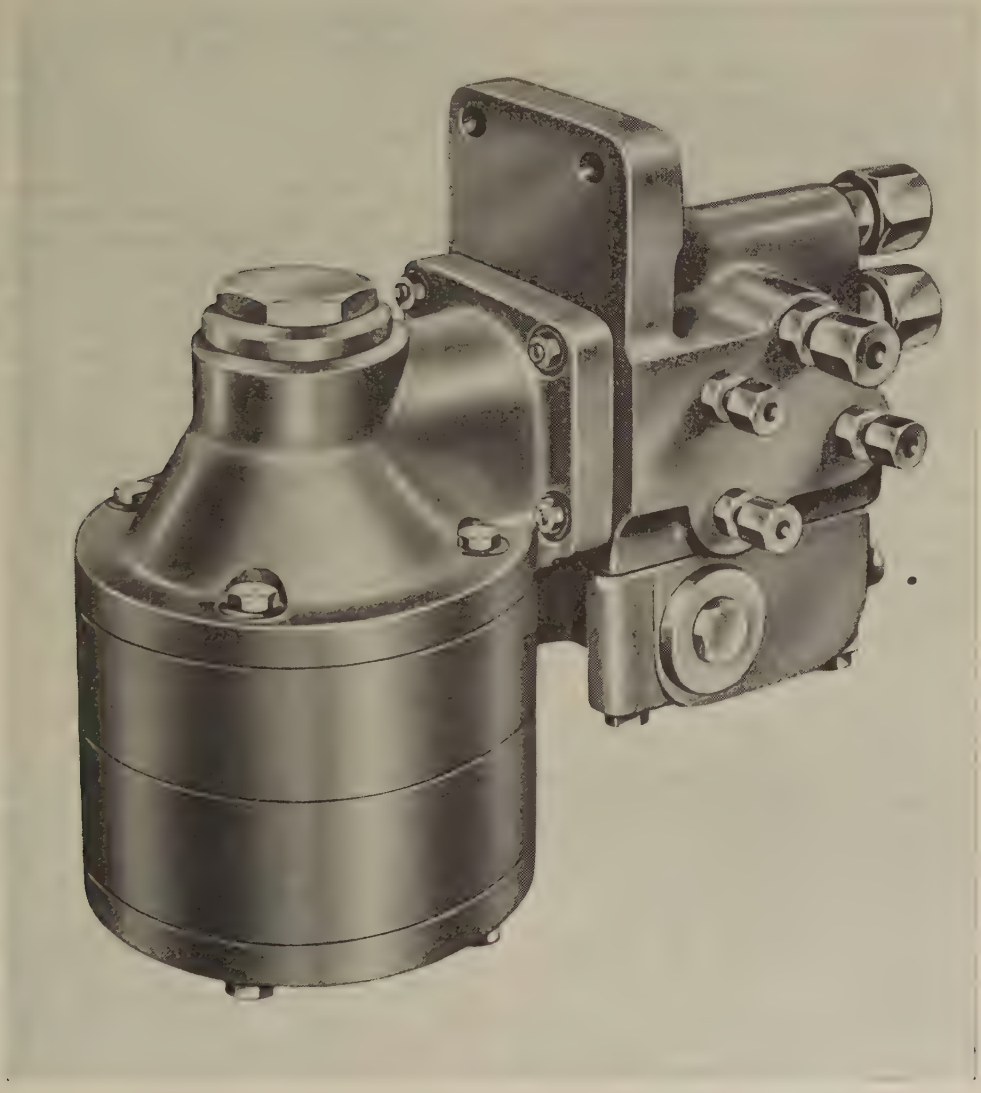
Oerlikon distributor, type LST1 for locomotives.

The Oerlikon type LST1 distributor for locomotives represents considerable pro-

gress as regards simplification and standardization of the brake layout of locomotives and railcars.

The LST1 type belongs to a series of different appliances based on assemblies of constructional elements with the following objectives in view :

1) distributor for locomotives, for goods, passenger and express trains with two ranges of pressures, for anti-slip brake;



Oerlikon brake distributor for locomotives, type LST1.

2) distributor for locomotives, for rail-cars with or without high speed brake and with anti-slip brake;

3) relay with the pressure ratios adjustable at will;

4) distributor to operate the compressed air brake on rail cars fitted with vacuum brake.

For all these appliances, the same fastening is used, this having more or fewer connectors according to the application. To replace a distributor here again there is no need to undo any piping. In addition the new distributor for locomotives, type LSTI, has the following advantages :

a) the pressure of the main reservoir can be used to feed the brake reservoirs which enable small cylinders to be used, especially with the quick acting brake. These small cylinders are desirable in view of the restricted space available on locomotive bogies;

b) the brake is inexhaustible as after each release the normal maximum pressure in the brake cylinder is again reached on the rapid brake action that follows;

c) the section through the admission valve is so large that one distributor can feed all the brake reservoirs on the locomotive in short intervals of time;

d) for the preliminary control of the anti-slip brake provided in the type LST1 distributor the pressure in the train pipe can be used, which makes any special pressure regulating valve or relay unnecessary;

e) the use of the LST1 distributor enables a large number of joints to be suppressed. This reduces the cost of erection.

The compressed air apparatus described above are based on the same modern principle of construction as the Oerlikon brake for goods, passenger and express trains, which was tested and thanks to its good features, was authorised to be used without any restriction in 1949 on international traffic by the Brake Sub-Commission.

[625 .251]

Braking of Diesel rail vehicles.

Results of tests and a review of experiences with different systems,

by George W. McArd, A.M.I.Mech.E.

(Diesel Railway Traction, January, 1951.)

In all railway workings the prime object before the operating staff is the transport of goods and passengers from one point to another in the shortest possible time consistent with safety. On the assumption that the track is all that can be desired, rapid transport involves three main factors, namely, ample engine power for the load to be hauled, correct signalling arrangements, and efficient braking. The last mentioned covers many other factors besides the actual power of the brake itself, and includes the layout of the brake, the type of retarding agent used, the design and condition of the equipment, and the skill of the operator. Other factors external to the brake influence the distance in which the stop can be made, such as rail and wheel tread condition, whether sanding is available, and so on, but those already named are perhaps the most vital.

In shunting, locomotive brakes, though important, do not figure so prominently in the designer's view as do those on the faster moving units, and it has often been pointed out that a second's delay when travelling at high speed may be more than sufficient to spell disaster, since a distance of 147 ft. is covered by every second's delay when running at 100 m.p.h. It is, moreover, possible to achieve a higher mean effective speed of the train throughout its journey by providing efficient and rapid braking, as the graphs in figure 1. clearly show, and for this reason, among others, brake equipment and its maintenance calls for careful consideration.

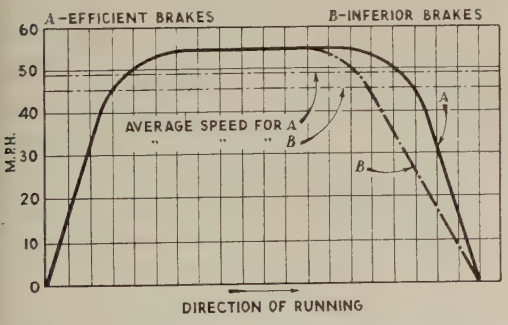


Fig. 1. — Graphs to illustrate the higher average speed obtained by efficient braking.

Simultaneous applications.

Where a train of vehicles is in question an effective method of applying the brakes as nearly as possible simultaneously on each vehicle must be included to avoid the bunching of coaches which otherwise occurs when the brake is applied. The quick-service application valve mounted on each cylinder takes care of this so far as the vacuum brake is concerned, while the operation of the admission valves on electro-pneumatic systems by electro-magnetic valves gives the desired result for the air brake, specially designed triple valves being used on normal air-brake systems. By such means retardation of the whole unit is achieved quickly without discomfort to passengers, and a deceleration up to 3 m.p.h.p.s. is regarded by many operators as the maximum desirable, with 2 m.p.h.p.s. as the more normal rate. For sudden emergencies, where safety of life and stock takes precedence over passenger comfort, a value up to 4 m.p.h.p.s. is permissible.

Braking methods.

Although the old-type shoe is still used on most vehicles, other means have been adopted for braking. Among these may be named the drum and disc brakes, and the use of the traction motors on electric units in what has come to be known in Diesel traction circles as dynamic braking. Whatever form the brake selected may take, the end in view remains the same, *i.e.*, the kinetic energy stored in the moving train must be destroyed in the required time and distance. Brake ratios up to 90 % were considered satisfactory in former years when speeds rarely exceeded 80 m.p.h., but with the increased speeds at which many Diesel expresses operate today, ratios as high as 250 % are used, provision being included in the equipment for the gradual reduction of this ratio as the speed falls. In passing, it should be emphasised that the weight factor influences directly the amount of kinetic energy to be destroyed, and this is one of the chief reasons why designers of high-speed rolling stock restrict the overall weight of their products wherever possible, consistent with other essentials.

Tests made at the University of Illinois show that the coefficient of friction between brake block and wheel varies according to (*a*) the pressure applied between block and wheel and (*b*) the rubbing speed on the block — otherwise the vehicle speed — being greater generally with lower shoe pressures and speed. A standard unit pressure does not appear to be practicable, since speed must be taken into consideration, but from the tests referred to it would seem that the safe limit for block pressures may be obtained from the value of 90 000 ft. lb. of work per second, this being the maximum value for energy destruction at the tyre. Even at this value the risk of melting the rubbing surface of the block exists, and the lower limit of 70 000 ft. lb. per second seems preferable for some classes of service. Figure 2 gives the results of tests conducted at the university in regard to the brake shoe pressures when applied at the three different speeds indicated, the stopping distances for each combination of speed and block pressure being shown, shoes measuring 3 1/4 in. wide and 14 1/4 in. long being used.

From what has been stated it will be obvious that heat dissipation is the crux of the problem, and where this is accomplished by the application of cast-iron shoes to the tyre periphery, the generation of relatively high temperatures may have serious repercussions in regard to the security of the tyre to the wheel centre, or, where solid forged-steel wheels are used, the cracking of the disc wheel. It was to safeguard the tyre and wheel attachment that many steam locomotives included in their design special water-cooling provision for the tyres where the engines were required to negotiate long grades with heavy trains.

Two methods are available by which the unit pressure on the blocks — and therefore the resultant temperature — may be decreased, that shown in figure 3 being the former L. M. S. R. compound shoe arrangement, while the clasp brake

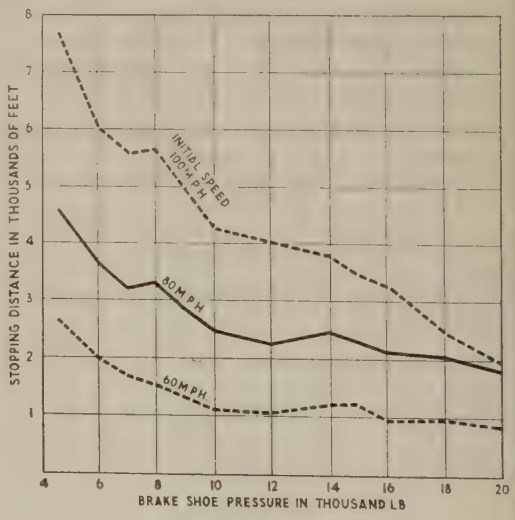


Fig. 2. — Relation between stopping distance and brake shoe pressures as obtained in University of Illinois tests.

layout seen in figure 4 is the method used on the « Merchant Navy » class locomotives of the Southern Region of British Railways. The latter has the additional advantage of eliminating the extra longitudinal pressure which the axlebox guide faces must sustain in the normal single, or equivalent, block application.

With drum brakes, difficulty may be experienced in some vehicles at the higher speeds owing to structural limitations which have cramped the designer in his natural desire to provide large-diameter drums, ribbed for air cooling, with a reasonably broad shoe surface. He has a distinct advantage in the fact that modern shoe linings afford

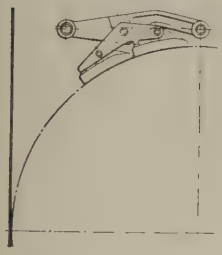


Fig. 3. — Compound brake shoes used by L. M. S. R.

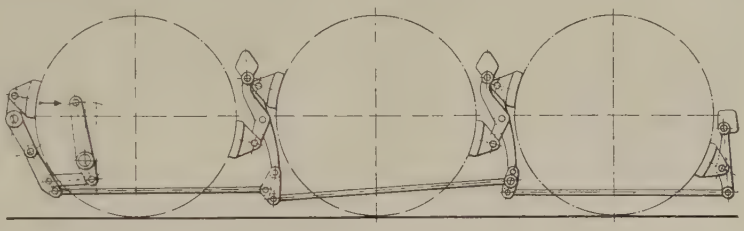


Fig. 4. — Clasp brake fitted to « Merchant Navy » class locomotives on the Southern Region of British Railways.

appreciably higher coefficients of friction than is obtainable with cast-iron shoes operating on steel tyres, and the further benefit that adjacent bearings do not suffer from floating grit as do those in the region of the cast-iron shoe brake. Years of design and running experience on road vehicles are available for the railcar drum brake designer, and, while there may be certain snags in the use of this type on vehicles which must operate equally in either direction of running, these are not regarded as unsurmountable, and will almost certainly be overcome despite the fact that experience on some lines has been unfavourable to their use. Research is being carried out by experts with extensive experience of drum brake design in complete assurance of ultimate success.

Three essentials of a good brake.

The three essentials of a good rail vehicle brake are as follows :

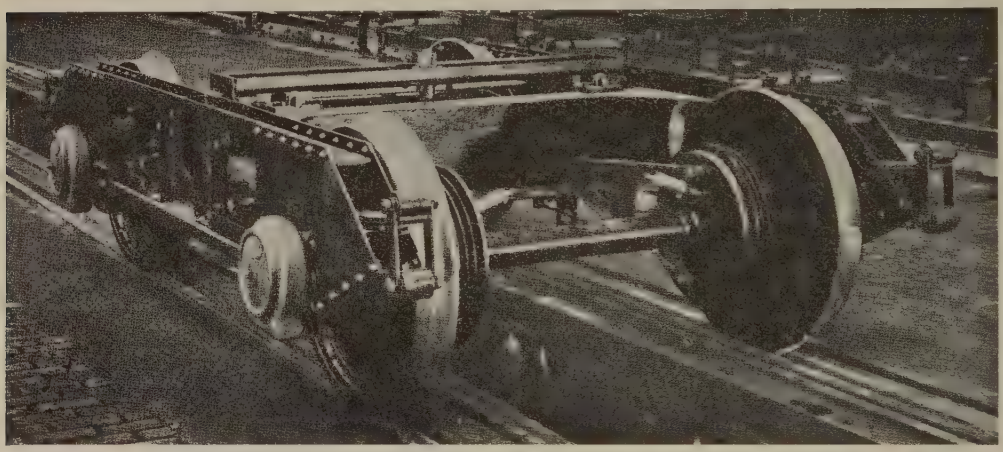
(1) tyre surfaces must not be interfered with by the application of retarding units, and the braking must be under such control as will eliminate skidding and consequent tyre wear and overheating;

(2) reduction of the number of pin joints in the operating gear, and therefore maintenance expense as well as loss of power and movement;

(3) the design of the brake must be such that its application will not involve the release of a shower of metallic grit, with consequent danger of wear to surrounding machinery and driving gear, and ill effects on electric driving motors. All these appear to be found in the drum brake, and the discarding of this type of brake by a number of lines would seem to be due to lack of experience of the operating department in maintenance and unwillingness of principals to take proper steps to have their staff trained, load per unit area on friction lining being too high for successful results, and brake drums made of unsuitable material.

The maintenance of a drum brake is a totally different affair to that required for the ordinary cast-iron shoe and its advantages would seem to justify the extra maintenance necessary. In the illustration

hereunder the carrying bogie is shown for a Diesel-electric railbus built by Armstrong Whitworth and purchased by the former L. N. E. R.; this vehicle was provided with drum brakes, which had an excellent record of service, due, without a doubt, to the quality of maintenance provided. Important factors in effective drum brake service are the design and proportions of the drum, the material of which the drum is made, and the composition of the fabric lining.



Drum braked carrying bogie for a Diesel railcar.

Disc brakes.

The disc brake is a relatively new departure and has been used on Continental and U. S. A. railroads with success. One of its many advantages is due to the facility with which the heat, generated while the kinetic energy of the train is being destroyed, can be dissipated without damage to the braked surfaces as occurs with the old-fashioned cast-iron block. Where the retarding effort of any brake should be at a maximum when the vehicle is travelling at top speed, the ordinary brake shoe fails, only reaching its maximum effectiveness as the vehicle speed falls to the lower ranges.

The disc brake, it is claimed, gives uniform deceleration at all speeds commencing from the instant of application, and will easily yield a deceleration of 3 m.p.h.p.s. without any discomfort to passengers when applied at speeds of 100 m.p.h. Thus, a train so equipped should decelerate to a stop from 100 m.p.h. in less than 2 500 ft. Another excellent feature of the disc brake is the easy control afforded on a long down-grade, heat dissipation being achieved at a rate which keeps disc and shoes well within their thermal capacities.

A good example of a coach bogie fitted with disc brakes is illustrated on page 620 in which the discs and operating cylinders are clearly visible. Another illustration, on page 622, shows the disc with the multiple fins provided between the disc faces; these fins not only provide an increased cooling surface, but also function as a rotating blower for the expulsion of the hot air. Special attention has been paid to the method of securing the disc to the wheel hub to permit the maximum of freedom

for the expansion of the disc when subjected to temperature changes.

Dynamic braking is a logical outcome of what is known in straight-electric traction operation as regenerative braking, but in the latter case, in addition to the valuable retarding assistance derived where motors are used as generators, the current produced — in theory at least — may be passed into the transmission line and be usefully employed by electric units hauling stock up the grade. This possibility does not exist in Diesel-electric traction in which the current generated must be dissipated through resistances or air coolers which may be mounted on the roof of the vehicle. Considerable braking power is thereby obtained, however, braking efforts as great as 95 000 lb. at 15 m.p.h. being available, with a minimum of 40 000 lb. at speeds ranging from 7 1/2 to 40 m.p.h. The normal air brake is used only for exceptionally heavy loads, or grades and in emergency.

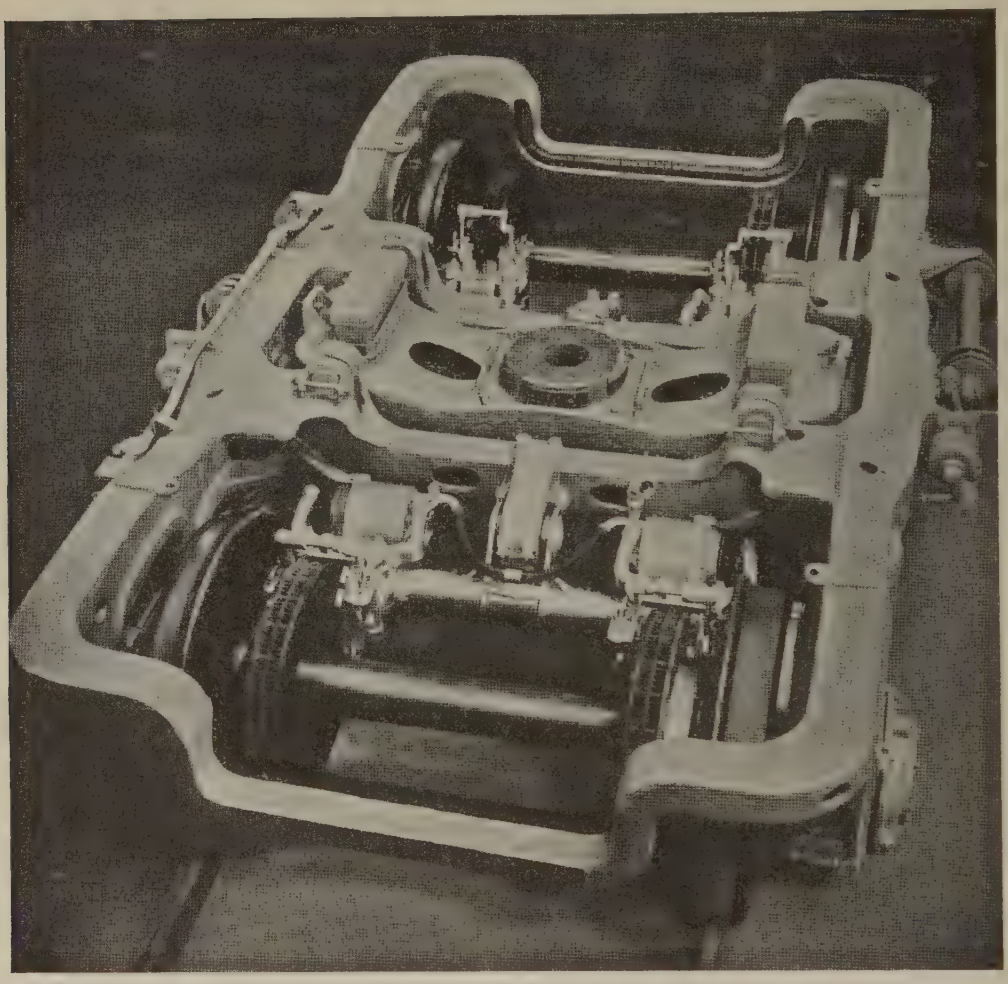
Electro-magnetic brakes.

Another type of brake which calls for reference is the electro-magnetic which uses the weight of the vehicle and the existing coefficient of friction between rail and brake shoe. Two disadvantages are experienced with this form of brake, however, namely, the destructive effect on points and crossings when these are traversed with the brake in operation, and the difficulty of making a good magnetic contact on all rail surfaces, new and worn rails varying appreciably in outline. A third objection which might be raised would be that such a brake depends entirely on the efficiency of a closed electric circuit rather than the breaking of a circuit.

The efficiency of a brake is a vital matter which appears at last to be receiving the consideration to which it is long overdue. By efficiency one naturally relates the initial force applied, multiplied by the mechanical advantage of the gear system, to the actual force applied at the wheel tread, in the case of the ordinary cast-iron shoe brake. In the usual arrangement of brake rigging the value of 75 % is approximately the maximum one could allow, and in some cases even this figure would be quite generous.

Efficiency is seriously impaired by the use of details — brake shafts and arms, crossbeams, and so on — in which the stress is too high, permitting considerable deflection of the detail when the full brake load is applied. A large number of included pin joints detracts from the efficiency of any brake system, as the slack in each joint must be taken up before any pressure can be applied at the vital surfaces. In most vehicles these pins are a slack, or easy, fit initially, and if no lubrication is provided, wear and rust quickly deteriorate the value of the joint.

Generally, brake rigging as normally provided until recently is inefficient, noisy, relatively heavy, and abounding in weak points, in any one of which failure may occur. The fact that safety straps are included in many vehicle designs to prevent broken rigging fouling the track is ample evidence that this has been recognised, and the ideal arrangement is that shown in figure 5, where a separate cylinder operates each brake shoe, compensation being perfect since it is obtained through the operating medium — compressed air. This scheme combines a slack adjuster, and as its mechanism is enclosed in a chamber after well greasing, wear is reduced to a minimum, with efficiency maintained at a high level around 90/95 %. The braking effort for the suspended brake block is taken off at point « B ». Where such a direct application is not feasible, a common method in the U. S. A. is to fit more brake cylinders than usual with fewer gear details. On bogie vehicles, for example, instead of having one or more cylinders slung beneath the coach underframe, operating linkages on the bogies through the medium of a single brake shaft, one, or possibly two cylinders are mounted on each bogie, thus simplifying the link mechanism.



Carrying bogie fitted with the Budd disc brake.

Braking in relation to train weight.

While considering the question of brake efficiency, it is interesting to recall a formula frequently used by railway engineers to ascertain the braking rate of any train in relation to its weight, the resulting figure being stated as a percentage of the train weight. The formula — percentage braking efficiency $= 3.34v^2/d$, where $v =$ the speed at the moment of braking (in m.p.h.) and $d =$ the stopping distance in feet — was explained by Mr. W. S. GRAFF-BAKER in a paper to the Institution of Locomotive Engineers in 1937, when he pointed out that its chief advantage lay in its independence of knowledge of the train weight, the formula affording « a reasonable basis of comparison between trains of different weights running at speeds which may differ within reasonably wide limits ».

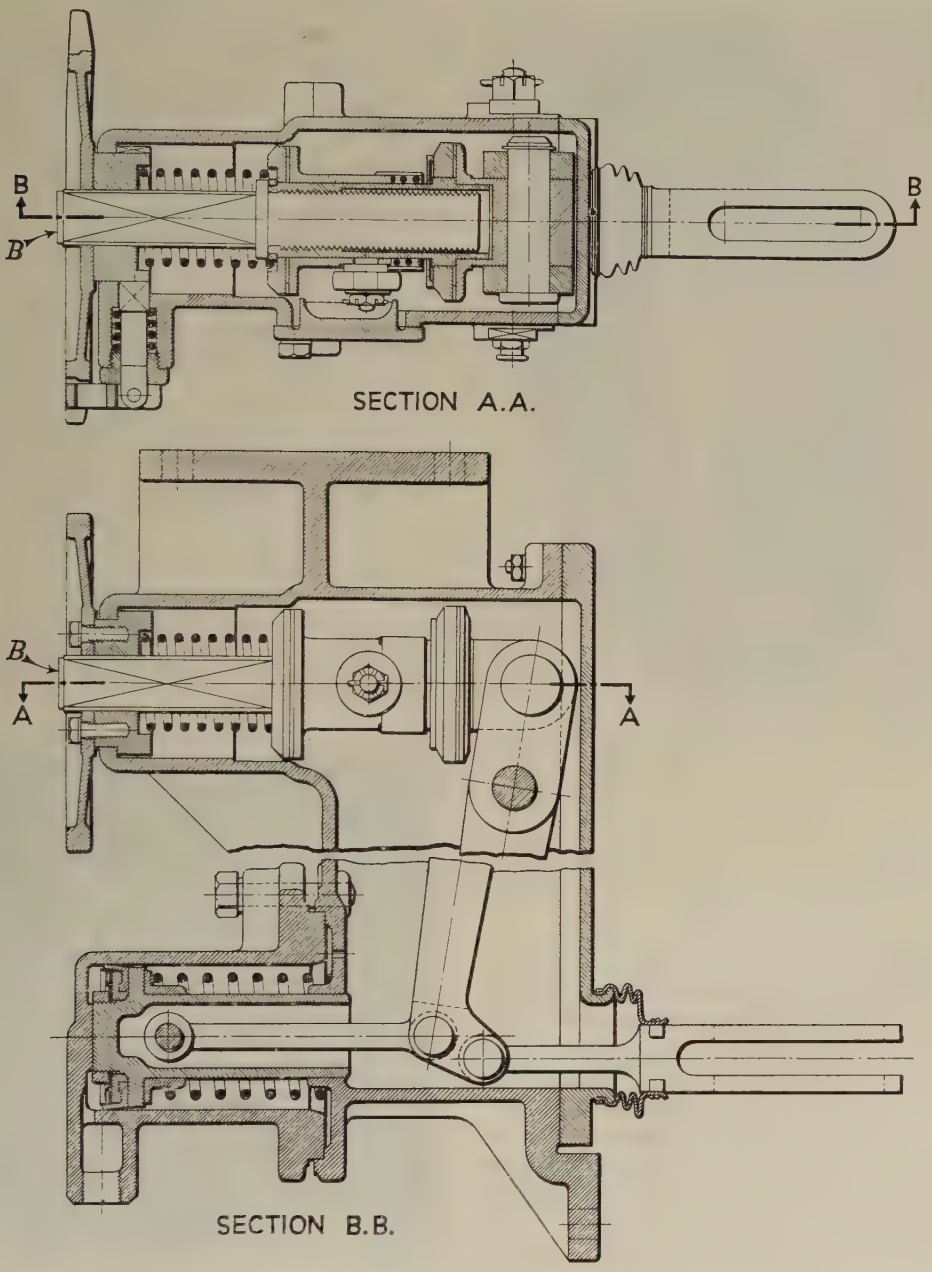
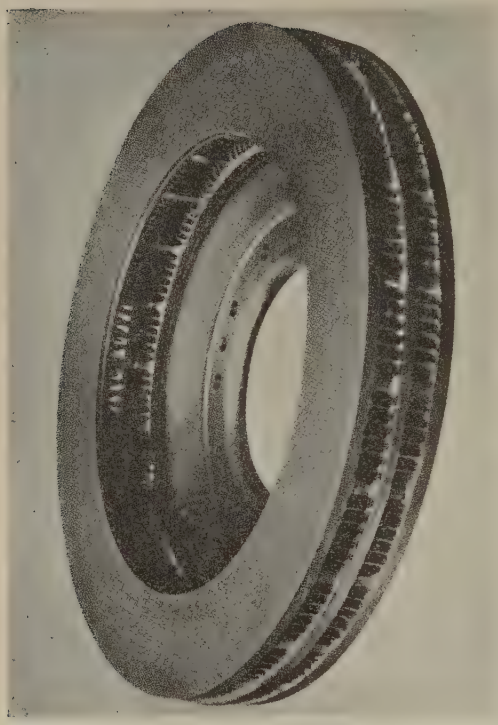


Fig. 5. — Brake cylinder and slack adjuster complete, Westinghouse Brake & Signal Co. Ltd.



Disc as fitted on bogie shown in the illustration on page 618.

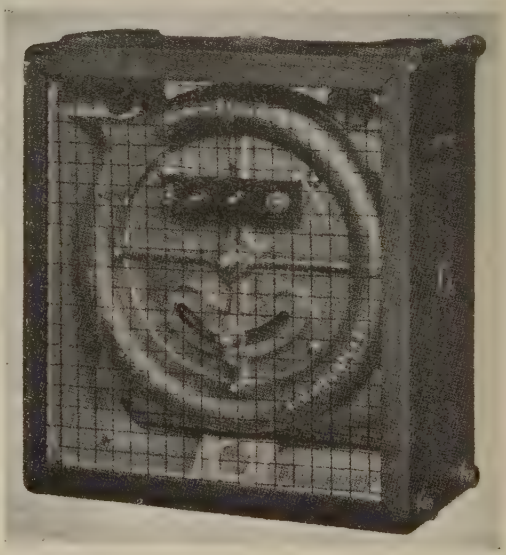
The application of the formula to the high-speed brake tests with a Diesel-electric locomotive as recorded in *Diesel Railway Traction* for November, 1946, gives, for the four ordinary stops (Nos. 1 to 4) percentages of train weight of 2.98, 3.12, 4.09, and 4.32 respectively, and for the fifth stop under emergency conditions 7.0 %, the total weight of the train with the locomotive included being 958 long tons.

An important factor concerns the coefficient of friction between wheel and block during the period of a brake application. In the early brake shoe tests conducted by Galton and Westinghouse in 1878 this coefficient was stated to vary as follows:

Speed	0	10	20	30	40	50	60
Coefficient	.326	.241	.191	.158	.135	.118	.105

Tests carried out in 1938 at the University of Illinois gave average coefficients, taken from start to stop, which vary according to the initial speed of the train and the total pressure on the brake shoe. These were shown graphically in *Diesel Railway Traction* for October 1938, and it will be noticed that the coefficient of friction decreased generally for all shoe pressures up to 14 000 lb. At speeds over 80 m.p.h. the coefficients took an upward curve.

When the application of the brake is in the hands of a skilled driver he can allow for the improved coefficient which occurs at the lower speeds, and brake accordingly. But it is possible to control the rate of retardation by the provision of a controller. In one type of instrument illustrated below two mercury tube switches are provided, one of which cuts off the brake cylinder pressure when a pre-determined rate of retardation has been reached: the other reduces the brake cylinder pressure if a slightly higher rate is attained. Each mercury tube has two electric contacts, one of which is placed near the bottom so that



Westinghouse retardation controller.

it is always covered by the mercury, and the other is placed at a certain distance above the level of the mercury.

When the brake is applied the momentum of the mercury causes it to move forward up the tube in the direction of running, and when the retardation rate reaches a certain value the mercury makes contact with a wire which causes a contactor to operate and de-energise the

The Netherlands Railways have introduced new straight-electric rolling stock since 1945 which operates at speeds up to 150 km.p.h. These units are provided with Westinghouse brake equipment designed with a view to an automatic control of the brake pressure in the cylinders to suit the speed at which the train is running. By this means reasonably short stopping distances are achieved from high speeds,

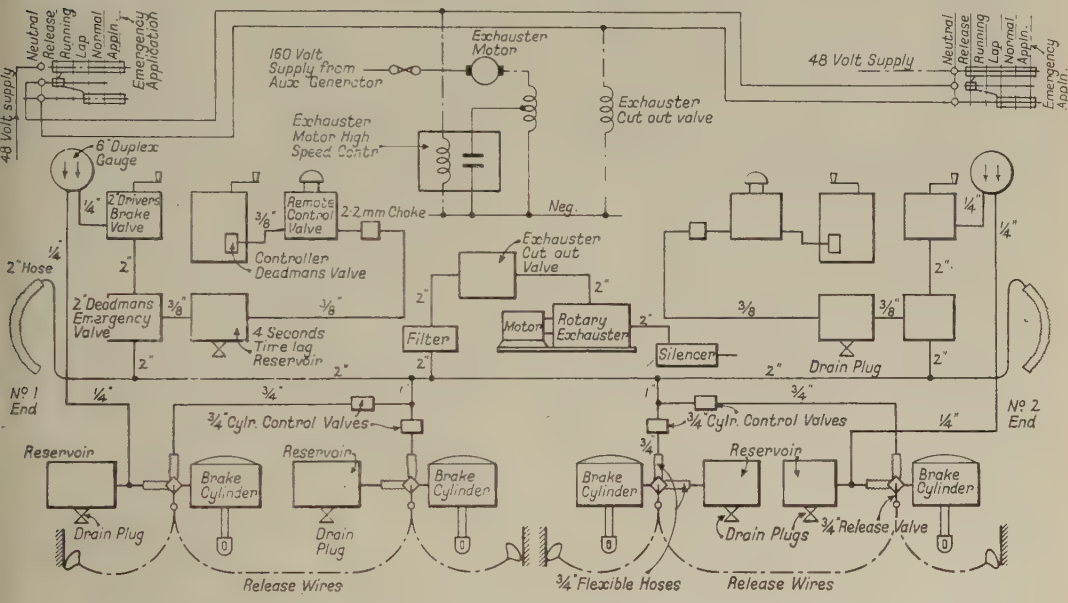


Fig. 6. — Arrangement of automatic vacuum brake for a main-line Diesel locomotive.

application magnets, thus preventing a further increase in brake cylinder pressure. As speed is reduced the rate of retardation increases, due to the higher frictional values obtainable between blocks and wheels at the lower speeds. The mercury therefore moves further up the tubes, and the contact in the second tube, which is set further away from the mercury than in the other tube, is made, and operates a second contactor which causes a reduction of brake cylinder pressure. The flow of mercury taking place in the tubes is damped by a restriction in the glass tube.

and as the speed falls, the speed-control equipment reduces the high brake forces used at top speed so that at every instant braking shall be ample for the requirements and yet never exceed the safe limit of adhesion between wheel and rail.

Vacuum brakes.

So far as brake equipments are concerned, the usual plan is to provide a straight air brake on the smaller units, with straight and automatic air brakes on the larger units, many of which operate in multiple. In the case of a main-line Diesel

locomotive which may be called on to work vacuum braked rolling stock, a straight air brake could be provided for the locomotive (using the self-lapping valve with its graduated application and release features) in conjunction with the vacuum brake on the train, the brakes on the locomotive being controllled by a special air-vacuum proportional valve. A typical schematic for a vacuum-braked locomotive is shown in figure 6, in which the usual provision is made for a deadman emergency application, this taking the form of a spring button in the main controller handle.

In somes cases, especially heavy shunters, a treadle arrangement is more suitable for the deadman application, the treadle being kept in the depressed state by the driver while the locomotive is in operation. In the event of his collapse, it is assumed that his body will fall away from the treadle, and thus ensure it freedom to rise (by spring action), so bringing the emergency valve into operation. Whether the treadle or the controller handle is used for the purpose, it is usual in shunting engines to duplicate the gear on each side of the vehicle, to allow the driver to operate from either side of his cab. The time taken to cross from one position to the other is more than covered in the ordinary course by the 4 or 5 sec. time lag which occurs in the operation of the emergency valve before the brake is applied.

Because of the greatly increased adhesion which may be obtained with an efficient sanding system — 40 % as against an otherwise top figure of 25 % — every care should be taken in the design of this auxiliary as well as in its erection, the jets of sand being concentrated on the rail as close to the points of contact of wheel and rail as can be achieved safely. The sanding pipes should be rigidly held in position, and if fine sand can be ensured, the ends of the pipes should be flattened to deliver a thin stream of sand about 1 in. wide to the wheel and rail contact. In some cases an emergency sanding operation is provided for, so that the retardation otherwise possible may not be lost by poor rail contacts at the critical moment. Such a scheme is naturally additional to that which is under the driver's control and comes into action automatically immediately the emergency brake application occurs.

[621 .431 .72 (45)]

The new Breda railcars, type ALn 880,

by Dr.-Ing. Franco Silvano Orefice.

(Ingegneria Ferroviaria, January, 1951.)

1. Technical development of the railcars with internal combustion engines.

It is about twenty years since the first railcars (which were then equipped with petrol motors) were turned out from the Breda Works, and their technical improvements have been realized gradually, following trials and experience in service.

Certain of their characteristics have been retained, such as driving positions at both ends, whilst others have been modified, such as the type of bodywork, tare, power, number and position of the motors.

Thus, after the first ultra-lightweight, 72-seater, cars fitted with petrol motors, there came a type which for several years was considered the standard, with 56 seats, all-metal body and two motors mounted on the bogies. These motors, originally petrol, were replaced by Diesel motors for reasons of reduced fire-risk and greater economy of operation.

A total of about 300 railcars were thus put into service; they were driven, as we have already stated, by Diesel piston engines, the power of which was successively increased from 2 × 130 HP to 2 × 160 HP, to enable them to meet service requirements more satisfactorily. At the same time, certain accessories were fitted and have been improved, to form the particular characteristics of the Breda railcars, as follows :

a) smoothness and maximum flexibility of the motor unit, obtained by using, amongst other things, *Ricardo* type precombustion chambers;

b) mechanical transmission with « fluid-drive »;

c) continuous mechanical gear change, with « Wilson » type epicyclic gears and electro-pneumatic control.

As regards operation, whilst railcars were originally intended to circulate singly, there has gradually arisen the need for making up railcar sets, in view of the public welcome for this new type of rapid, nice and comfortable service, which was particularly suitable for the Italian railway system with its numerous secondary lines having frequent stops and varying gradients.

The railcars therefore increased in weight, and were fitted with buffing and drawgear of the normal type, in place of the bumpers and drawhooks of the automobile type; consideration was especially given to the possibility of multiple drive, which was realized by recourse to fairly complicated electrical circuits, and allowed the driver to control from his cabin up to four Diesel motors of two coupled vehicles. Multiple operation also gave rise to the need for providing the travelling public with a fresh amenity — the possibility of moving from one vehicle to another during running.

All these requirements gave rise to the latest type of railcar ALn 880, designed and built immediately after the world war with Italian labour and materials, to specifications drawn up by the State Railways.

2. Technical characteristics and features of the new type.

Practical operation of railcars demonstrated the necessity of providing vehicles

which would fulfil the following principal conditions :

a) *maximum capacity* in regard to available seats, and possibility of a high degree of « flexibility in operation »;

b) *space available* inside for auxiliary services (luggage racks, postal compartments, toilet);

c) *communicating gangway* between vehicles;

d) *appreciable economy,* even at full load;

e) *smooth running and comfort* much superior to that provided by road transport services.

All these points must naturally bear relation to the services in which the Italian State Railways intend to use the cars; that is to say, they must provide, on non-electrified lines, a fast service, at low operating cost, sufficiently « flexible » to allow for easily adaptation to the volume of traffic.

These conditions are completely satisfied by the new *Breda* ALn 880 type railcars, by the provision of a number of arrangements which we shall describe in more detail later, but which may be summarised here, as follows :

— 80 available seats per motor or trailer vehicle, with provision for meeting greater demands by marshalling into sets of two motor and one trailer car, all with communicating gangways, as in normal main line trains;

— provision of luggage compartments and postal services, toilets, entrance, vestibules and gangways perfectly suited to their purpose;

— a through gangway (in spite of the streamlined exterior) which meets the following conditions :

a) a driver's cab free from all obstacles, providing *complete and unobstructed view* of the line;

b) no *detachable* accessories to be found room for, or to occupy useful space;

c) two vehicles can be *coupled together in a minimum of time;*

d) driver's cab completely weatherproof;

e) cab can be isolated when being used by a driver;

f) manual operation, without auxiliaries which are liable to defects or damage for any reason or cause :

— high-power motors, permitting the haulage of a trailer at speeds in excess of 130 km/h (80 m.p.h.) on the level at full load. At the same time, the motor is of reduced dimensions and is located under the centre of the body to leave the whole of the floor space free for provision of seats, services, etc. The use of a single motor, in place of the two so far used, is justified by the experience of the Italian State Railways, which has been that motor failures represent a minimum percentage of the total causes of railcars failures;

— maximum passenger comfort, with commodious modern seats with springs and rubber upholstering, spacious accommodation for hand luggage, luggage-racks, warm air heating, fluorescent lighting and individual incandescent lighting with light fittings under the luggage racks operated by nearly switches.

All these characteristics make the *Breda,* type ALn 880, railcar, one of the most modern vehicles of its kind, capable with suitable furnishing of providing de luxe services, with bar, dining facilities if required, Pullman saloon, etc.

3. Features of design. — Materials used.

The overall dimensions of the new railcar are shewn in figure 1. The car is of standard gauge (but there is already a slightly smaller version of metre gauge) and can negotiate curves of 90 m (295 yards) radius.

Speed on straight and level sections exceeds 130 km/h at the normal power output of the motor, which develops more than 460 HP; severe and prolonged acceptance trials have been carried out with the motor on a test bed.

The weight in running order is about 43 tons, made up as follows :

Body	21 000 kg
Bogies	11 500 kg
Motor and accessories	9 000 kg
Fuel, oil, water and sand	1 500 kg
Total	43 000 kg

siderable compression forces which develop in this portion of the body, the secondary members are sufficiently compact to avoid billowing of the plates. To resist shearing the panels are reinforced by vertical struts and the window lights have been shaped to the contour and surrounded by a « hem » to avoid a dangerous concentration of stress.

The frame, in particular, must carry and distribute, in line with the remainder of the structure, the concentrated weight of the motor, which rests on four bearings with a suitable intermediate bed and double flexible hangers.

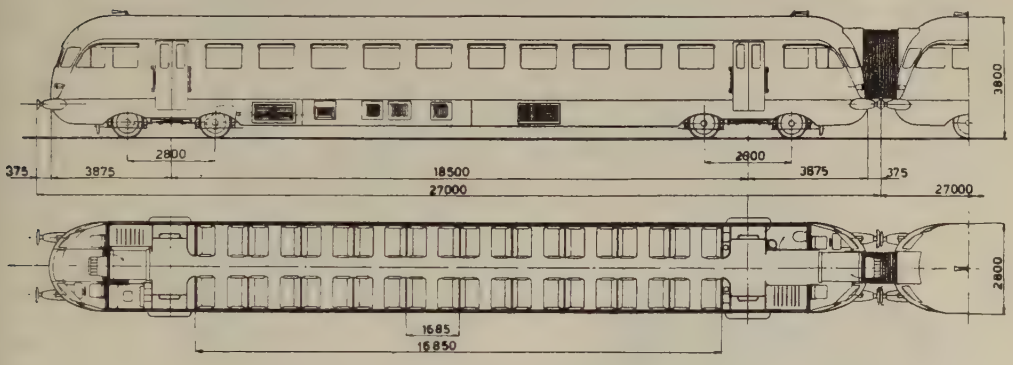


Fig. 1. — Side elevation and plan of railcar with through gangway.

It will be seen that the dimensions of the vehicle are proportioned to make full use of the rolling stock gauge, to provide adequate seating space and smooth running through curves, even with the vestibules coupled. This latter characteristic is due, in particular, to the judicious spacing of the pivots, which is at 18.5 m (20.22 yards).

The body, constructed on the tubular beam principle, is made up of plates and pressings of standard quality steel, type Aq 42.

The basis of design calculation therefore, presupposes that the full cross-section is resistant area and in order that the roof should be capable of supporting the con-

Static load tests on the body framing have confirmed that the body fulfils the prescribed load conditions, both as regards the maximum internal demands on the various parts (measured by extensometer) and also the elastic deformation under a maximum load corresponding to the total static load and dynamic overload.

Figures 2 and 3 show the completed railcar and the harmonious exterior aspect with its flowing lines, shapely curves and full aerodynamic form.

4. Construction. — Acceptance and stationary tests.

The greatest care has been taken with the welded construction, in order to obtain

Fig. 2. — Exterior of the vehicle.

a homogeneous and well assembled whole, even when, for manufacturing reasons, they are made in separate component parts.

All the various components are manufactured in series, by means of jigs, which guarantee that they will all be identical and that all the holes drilled will correspond. The different components are then assembled on large jigs which make it possible to assemble the sides, the frame, the roof and the ends separately; these parts are then welded in turn and form the tubular framework of the body (fig. 4). After this, the floor, wooden framework, ceilings, pannelling, and interior fittings as well as all the accessories are assembled.

Fig. 3. — End view, gangway retracted.

During construction, the various parts are checked against the drawings several times, and the quality of the welds checked, to make sure the tolerances allowed are not exceeded.

The metal framework of the prototypes in addition underwent static tests, to make sure that the deflections under given loads corresponded to the results of the calculations.

First of all, the metal framework was subjected to a load corresponding to the actual weight of the body, then to the maximum load laid down, and finally, to a load equal to the sum of the two previous loads plus the dynamic effects of running. During these tests, the maximum deflection which did not exceed 16 mm (5/8″) was checked, together with the stresses in the main components by means of mechanical extensometres fixed at predetermined points.

The stresses measured were of the order

of 2 to 4 kg/mm² (1.269 to 2.539 tons per sq. in.) on the average; in other words the metal components under full static and dynamic load had a safety coefficient of about 10.

After the tests, all the components returned to 0 when the load was removed, which proved, as expected, that they were well within the field of elastic deformation.

form a bearing for the floor. The longitudinals and cross-bearers are 4 mm (5/32″) thick.

The underframe has a particularly interesting feature at each end, where spacious platforms, of caisson section, form bearers for the bogies and at the same time, entrances to the car.

At the end, there is a robust headstock,

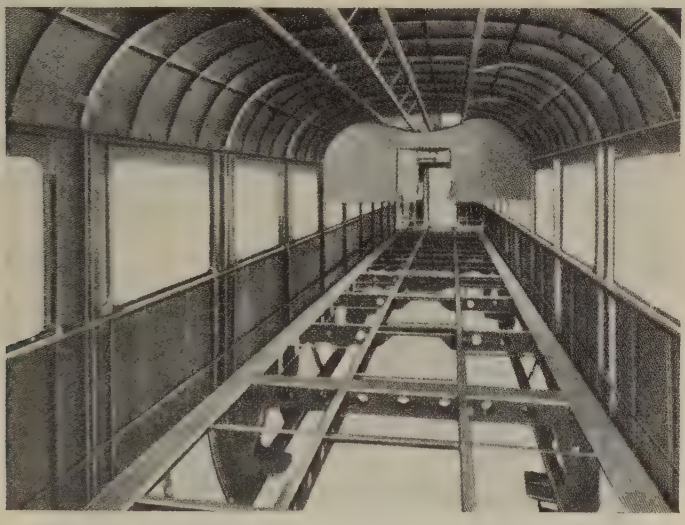


Fig. 4. — Metal framework.

5. Description of the body.

Metal framing. — The facing is of steel plate, 1.5 mm (0.059 in.) thick, electric-arc welded and fixed to a framing of three longitudinals (bottom, centre and top) and vertical struts. The framing members are specially designed steel stampings of suitable forms and sections, the plates being spot welded to the framing.

The underframe comprises four C-shaped steel pressings (the two inner members being drilled for weight reduction) connected by a suitable number of cross bearers of similar shape, which together

6 mm (15/64″) thick, for carrying the buffing and draw gear.

All frame members are connected by electric welding.

The roof is made up of small L-shaped curves, alternating with larger curves, covered with 1.5 mm steel plate, electrically welded. Area of free plate has been kept to a minimum to avoid billowing of plates subject to compressive stresses.

From the centre of the underframe are hung strong steel brackets, welded to the longitudinal and cross members, to form a bearing for a secondary underframe, on

which, as we shall describe later, are mounted the motor and its allied parts for transmission and control.

The nett weight of the framing described above is 9 000 kg (19 840 lbs.).

Furnishings. — The interior of the vehicle is subdivided to form the following main compartments :

— a compartment for 80 passengers (fig. 5) with small partitions forming three semi-compartments, the object of this being to allow simply, for operating purposes, possible separation of classes or division between smokers' and non-smokers' compartments;

— two entrance vestibules, with outer doors, sliding type, with electro-pneumatic control;

— two luggage compartments, with service compartments below;

— a toilet compartment;

— a postal compartment;

— two driver's cabs, with accommodation for train conductor (fig. 6).

The panelling of the passenger compartment is in aluminium plate, faced with green marbled linoleum, whilst that of the other compartments is also of aluminium plate, painted in suitable colours.

The flooring is of special timber (« paniforti »), 20 mm (2 5/32″) thick, covered with grey and green linoleum. The angles formed by the floor and walls are rounded to facilitate cleaning. Below the floor is a « superopaque » layer of thermic and acoustic insulating material, protected by two thin steel plates.

Fig. 5. — Interior of the compartment.

In the walls and roof, bituminous felt and cork have been used for thermic and acoustic insulation.

The compartment ceiling (fig. 7) has a characteristic double arch form, which provides for a central warm air distribution duct and for a long glass screen for fluorescent lighting. At the same time, the special form of the roof is well adapted for the gradual extraction of air and gives the maximum facility for the placing of hand-luggage on the large, specially-designed lateral racks. The brackets of these racks

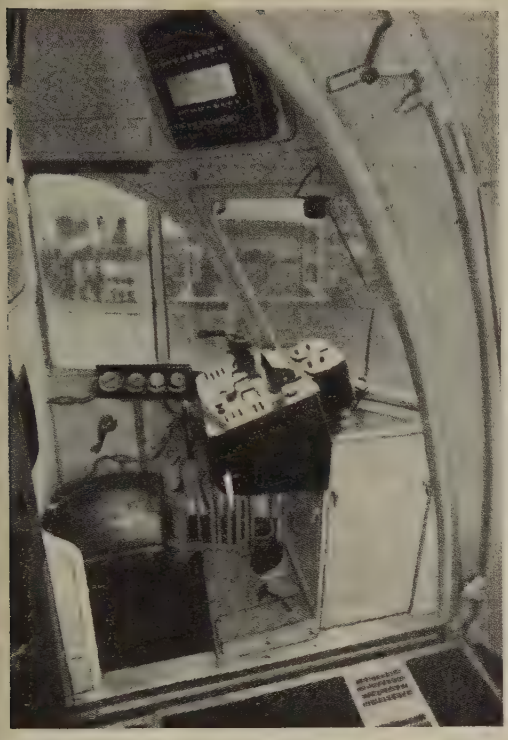


Fig. 6. — Driver's cab, driving side, with movable corridor retracted.

are also used as fittings for the individually-controlled reading lights, separately connected to a circuit suitable for incandescent lights.

Modern seats, trimmed with green velours and clear maroon vynilic art leather, and resilient cushions with springs and foam rubber, provide maximum comfort for the passenger.

Special mention must be made of a device located at each end of the vehicle, which provides for coupling, with through gangways, to a second vehicle (fig. 8).

In essence, this comprises :

— a corridor section, running on its own rollers, completely rigid, provided at the end with a bellows allowing normal coupling to a second vehicle;

— a removable section of flooring;

— a streamlined end door, sliding into the roof by the operation of a crank handle.

The operation of coupling together, which is extremely rapid (3-5 minutes), is very simple, and the sequence of operations required is as follows :

a) unlock and lift the end door;

b) push out the movable part of the cor-

Fig. 7. — Air distribution duct and fluorescent lighting.

Fig. 8. — Movable corridor, gangway and bellows vestibule in retracted position.

ridor until the bellows and a part of the gangway itself are through the doorway;

c) lock the corridor by lifting part of the floor, which is done in such a way as to form a passage without steps;

d) couple bellows in the normal way.

For uncoupling, the sequence of operations is reversed.

Practical tests have shewn that the operations are easy and quick. When uncoupling is effected, there is no loose part to be left occupying space in the vehicle.

There are no special features in the buffing and drawgear; they have been designed to assure working with any Italian State Railways vehicle.

6. Brief description of the auxiliary fittings.

The railcar is provided with a large number of auxiliary fittings, of which we shall attempt to describe the main features :

Brakes. — Automatic, adjustable, Westinghouse compressed air and direct types, with two operating valves in each cab, worked by four cylinders mounted two and two on each bogie; two mechanical compressors worked by the motor to operate the air brake.

Hand operation is by wheel in the driver's cab, acting on the bogie under the cab only.

Heating. — Forced air, with circulation from above the interior of the car. A proportion (about one third) of the circulated air is taken in from outside; the remainder is recirculated.

Two heater units take about 44 000 calories/hour from the exhaust gas and transmit it to the air circulated by suitable fans.

The installations is regulated by thermostat, with compressed air servo-regulators.

Lighting. — Two systems, incandescent and fluorescent. The former is fed in the normal way from two lead accumulator batteries on the vehicle. The batteries are recharged by a « Stones » 6.5 kW dynamo.

The second installation draws its current from a motor-alternator group at 400 cycles, the motor being energized at 24 V from the batteries. The fluorescent lamps are contained in a special lighting fitting along the compartment roof and in four ceiling lights over the vestibules. All other points have incandescent lighting; this system is also used for the emergency lighting, consisting of individually-controlled roof-lights under each luggage rack bracket.

Door control. — The entrance doors, pneumatically-operated, are controlled electrically, by the driver, through a gear system.

Various controls. — All controls to the driving unit are electric or electro-pneumatic.

7. Description of the bogies.

There are many new features in the bogies, which have as the standard components, a frame of closed box beams, completely arc welded, and bolsters also welded to form a rigid « monobloc » frame. The swing bolster is also of the same type. The two bogies of each railcar also differ from each other, as one of them carries all the transmission equipment (bridges, special axles, intermediate transmission and reversing gear [fig. 9 and 11]), whilst the other is a carrier only (fig. 10).

Another difference is in the type of body support which, on one bogie, consists of slipper blocks and on the other bogie rests on the centre pivot. In this way, the body is not subject to torsion resulting from different levels of the swing bolster, as is the case with four-point bearing.

Finally in the driving bogie, the motors and transmission transmit their reactions to the bogie frame by means of articulated arms.

Furthermore, the technical advantage of these bogies rests particularly in a new conception of flexible suspension and in the method of guiding the swing bolster.

The flexible suspension is dual; two laminated steel springs, with a high load capacity, support the swing bolster and provide a measure of control for the recoil; eight rubber springs of a special type (fig. 12) provide the axle suspension and at the same time form a very good shock-absorber group.

Each axlebox (fig. 13) located inside the corresponding wheel, is of the roller bearing type; it is of cast steel, with two cast-in cups for the rubber springs (fig. 12); there are no axleguards or axlebox guides in the normal way in which these are conceived. In their place are two strong steel pivots, welded to the bogie frame and passing through the centre of the couples but *having no metallic contact* with the axles or the axlebox body.

The rubber springs *not only form a real suspension* but at the same time serve as a flexible link between the driving axles and the remainder of the vehicle; it thus provides a shock absorber and noise eliminator in one fitting, and is not subject to wear (as with normal axlebox guides) owing to the complete absence of friction between metal parts. An immediate and not inconsiderable advantage of the system lies in the elimination of lubrication and need for periodical inspection of rubbing parts.

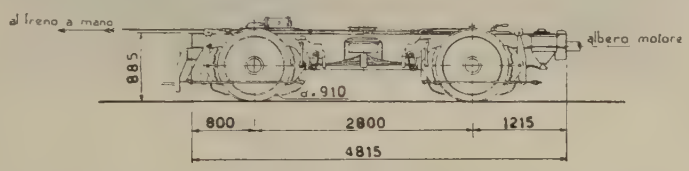


Fig. 9. — Driving bogie.
Albero motore = driving axle. — Al freno a mano = hand brake.

The rubber spring, R. I. V. type, works in combined shear/compression; as it is *precompressed*, it has when free, a much greater volume than when in service, which is a considerable advantage should there be any heating, which is most injurious to rubber. The mass of rubber is, in fact, very large.

We shall deal later with the practical results obtained with this suspension.

As we have already mentioned, another new feature lies in the method of guiding the swing bolster, which is kept in place

by two steel tie rods, linked by rubber buffers, on one hand to the bogie itself and on the other hand to the bogie frame. This arrangement has already been used in America (where, however, it is applied to the exterior of the bogie) but does not seem to have been used in Europe, or at any rate, not in Italy. The two tie rods hold the bolster and return it constantly to the centre, limiting its movement (to the point at which the slide blocks would become ineffective), and transmit to the body of the car the stresses which are « filtered » and damped by the silent-blocs.

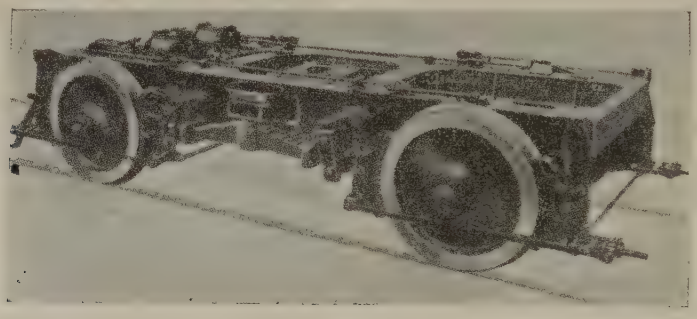


Fig. 10. — Carrying bogie.

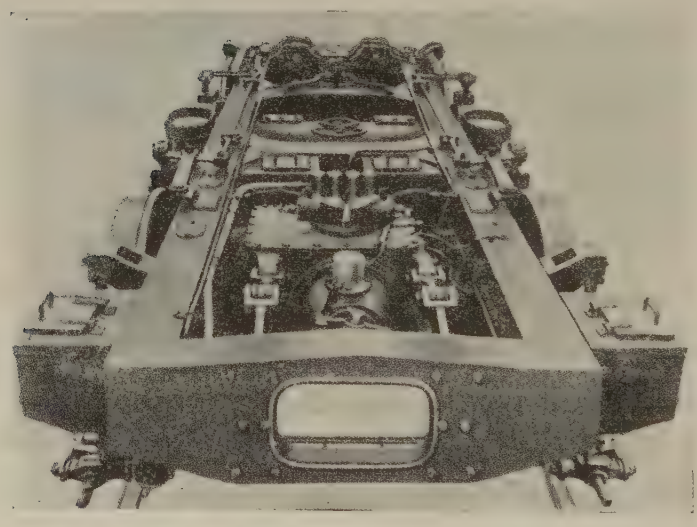


Fig. 11. — Driving bogie seen from above.

The bogies have a wheelbase of 2 800 mm (5′ 11 1/8″) a normal spacing, wheels of 910 mm (2′ 11 7/8″) diameter, and weigh respectively : driving bogie 6 360 kg; carrying bogie 5 100 kg.

8. Motor unit.

An important characteristic of this type of car is to have all the main parts forming the motor unit grouped on a special robust chassis, slung beneath the vehicle

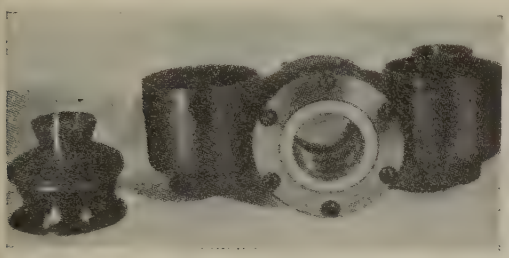


Fig. 12. — Roller bearing box with spring seats and rubber springs removed.

(fig. 14). On this boat-shaped chassis are located the motor, the hydraulic coupling, the gear case, the A C and D C current generators, the circulation and injection pumps, etc. On the other hand, the water cooling for the motor, fuel tanks and brake

mounting; the motor is carried by the frame on a series of silent-blocs, so as to give two degrees of resilient mounting designed to absorb vibrations of various frequencies.

For inspection, there is a removable cover, and the entire chassis can easily be withdrawn from beneath the body by means of a simple carrier.

The Breda D 19 motor (fig. 15) is designed for rail traction and its exceptional robustness is due in part to the fact that the gearcase and motor block are a single steel casting. It is of the Diesel, flat, three cycle type, fed by turbo-compressor and has precombustion chambers.

Its principal characteristics are :

Bore	135 mm (5.314 in.)
Stroke	190 mm (7.480 in.)
Number of cylinders . .	12
Maximum speed . . .	1 500 r.p.m.
Maximum power with supercharger at 1 500 r.p.m.	460 HP
Total cylinder capacity .	32.6 l
Approximate weight . .	2 800 kg (6 172 lbs.)

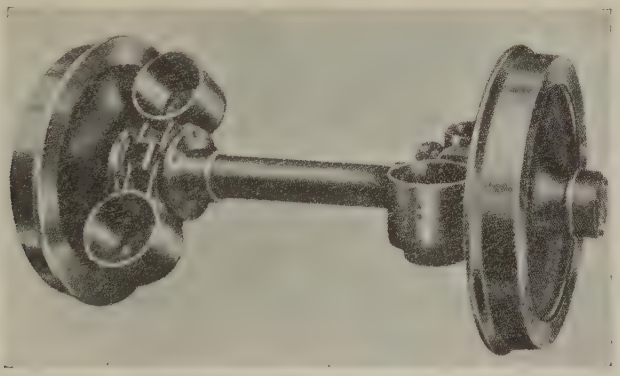


Fig. 13. — Axle with roller bearing boxes assembled and seats for rubber springs.

apparatus assemblies are connected directly to the underside of the body.

The chassis carrying the motor and other parts enumerated rests on brackets fixed under the body through suitable rubber

The pistons are of aluminium alloy, extruded and heat-treated; the push rods are of forged steel and the big ends have adjustable bearings; the cylinder jackets of special nitrous cast iron are easily remov-

able; they are cooled by the circulated cooling water of the motor block.

Circulation is effected by two electric pumps, the motors of which are fed by the dynamo.

with the motor driving in either direction of travel. The equipment has two large-area re-cooling radiators in the lower casing of the car.

The air taken in through suitable orifices

Fig. 14. — Arrangement of the motor.

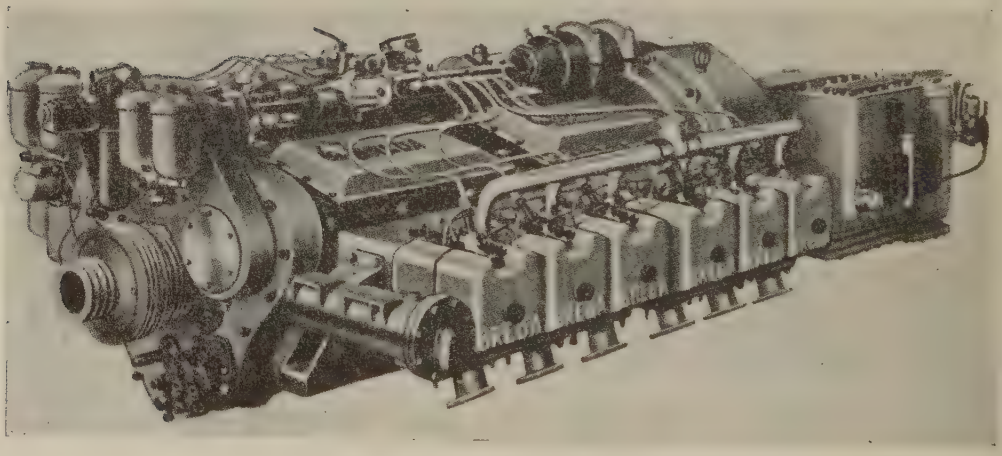


Fig. 15. — Motor with hydraulic coupling and gear change.

Lubrication is forced.

The water cooling system of the motor is very interesting and quite new; it is thermostatically controlled and operates

in the casing is expelled after passing across these radiators, transversely to the car.

The air current for each group is created by electric blowers located in the middle

of an equal number of conduits, which are designed to avoid loss of load.

The blower motors are fed with three-phase current, produced by alternators in two special groups worked by the Diesel motor; baffles controlled by thermometers with electrical contacts, located in the air passages, switch on and off some or all of the motors, which provides adjustment of the air intake so that the capacity of the cooling system is constantly proportionate to the calories in the circulated water.

Starting of the Diesel motor is by two small synchronised electric motors.

The motor is fed by two turbo-compressors, the rotors of which are operated by the exhaust gas through turbines. The gas is afterwards released through the car roof.

Before entry to the compressors, air is cleaned by oil filters and then fed through appropriate ducts.

The motor is connected to the gearbox by a Vulcan-Sinclair hydraulic coupling, in which a driving rotor, solid with the driving shaft, transmits the movement to a driven rotor, which is solid with the primary shaft of the gears, by means of the induced movement of a mass of oil which circulates in specially designed cavities in the two rotors. The purpose of this coupling is to damp out torsion vibrations transmitted by the motor shaft, which are particularly noticeable when starting and in changing gear.

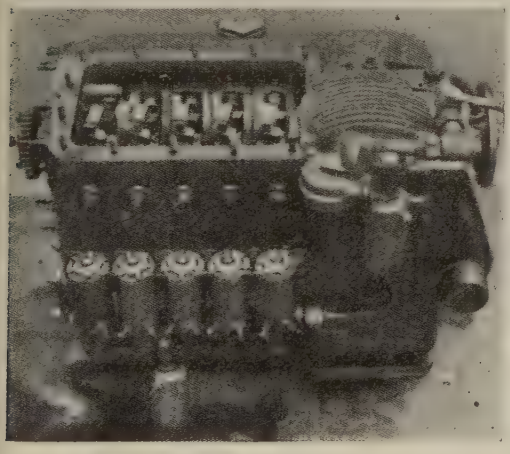


Fig. 16. — Epicyclic gear case, with cover removed.

The continuous mechanical gear change is of the preselective type with epicyclic gears and five ratios (fig. 16).

Gear selection is effected by six small air cylinders and corresponding electro-pneumatic valves, one for each speed and one for neutral.

The shafts from the gear box to the main transmission box and from there to the secondary transmission box are of the telescopic type with cardan joints at each end.

Movement is transmitted to the bogie driving axles by means of two cylindrical gear wheels, three conical gears in the main transmission box and two conical wheels in the secondary box. In the main box, a claw-type clutch provides for reversing the direction of rotation of the shaft by means of an electro-pneumatic servo-motor cylinder.

A complicated electrical installation constitutes the nerve system of a modern rail-car. It will be sufficient here to outline the main functions to give an idea of the careful design which is necessary.

Firstly, the motor controls are electro-pneumatic; they also provide for working two similar cars coupled together for multiple working and the electric control is the only way of ensuring the synchronous and perfectly instantaneous operation of all the controls. To couple two vehicles for multiple working — that is to say, with one driver — it is necessary in addition to provide control from a single driving position for the motors of two vehicles. This is a duty which is fulfilled by electrical indicators of a specially designed type.

There are, in addition, the fittings for the dual system of lighting (fluorescent

and incandescent), with their regulators, generators, batteries, etc.

It is necessary also to provide for the door control, which is also electro-pneumatic, and for the sanders.

9. Results obtained.

Some remarks on the results obtained will show clearly the perfect behaviour of the body, bogies and motor unit, even at the highest speeds.

Whilst the maximum normal speed for which the car was designed is 130 km/h, it has been able to reach easily, and to exceed, 145 km/h (90 m.p.h.) during its first trials.

No critical speed has been found; the body of the vehicle is completely free from vibration by the motor whether at maximum or minimum speed of rotation, at rest or at the maximum speed of travel.

The special bogie suspension, which we have already mentioned, has confirmed in practice all the qualities claimed for the design; in fact running is smooth, flexible and mechanical vibration due to irregularities in the road, rail joints or track equipment are not transmitted to the body. Inside the body a passenger is able to converse or rest equally as well as in any hauled vehicle.

Acceleration and braking trials, even when extended, have shewn no irregularity.

The motor is well balanced and produces no oscillation of the chassis; during acceleration and braking, the movement of the chassis was of the order of one or two millimetres (approx.) only.

10. Trailer vehicles.

Trailer vehicles have been built with profile, dimensions, constructional characteristics and interior arrangement identical with those of the railcars.

They are, of course, without any driving components and have two carrying bogies only, but they have two driving cabs and all electric connections and pneumatic connections to allow using the trailer vehicle as the pilot car.

The main difference between the trailer and the railcar (at least, in the first vehicle), is in the different arrangement of the heating system.

Since the trailers cannot, of course, obtain heat from the calories produced by a motor, a small oil-fired boiler is provided to heat water which circulates in a heat exchanger similar to that of the railcars.

From there the installation is identical with that of the railcars, with forced air from the exchanger to the interior of the vehicle, by distribution ducts and suitable exhaustion.

The dynamo for electric power and lighting in trailers is arranged on the bogie and worked by one of the axles through a belt system.

[625. 215 (73)]

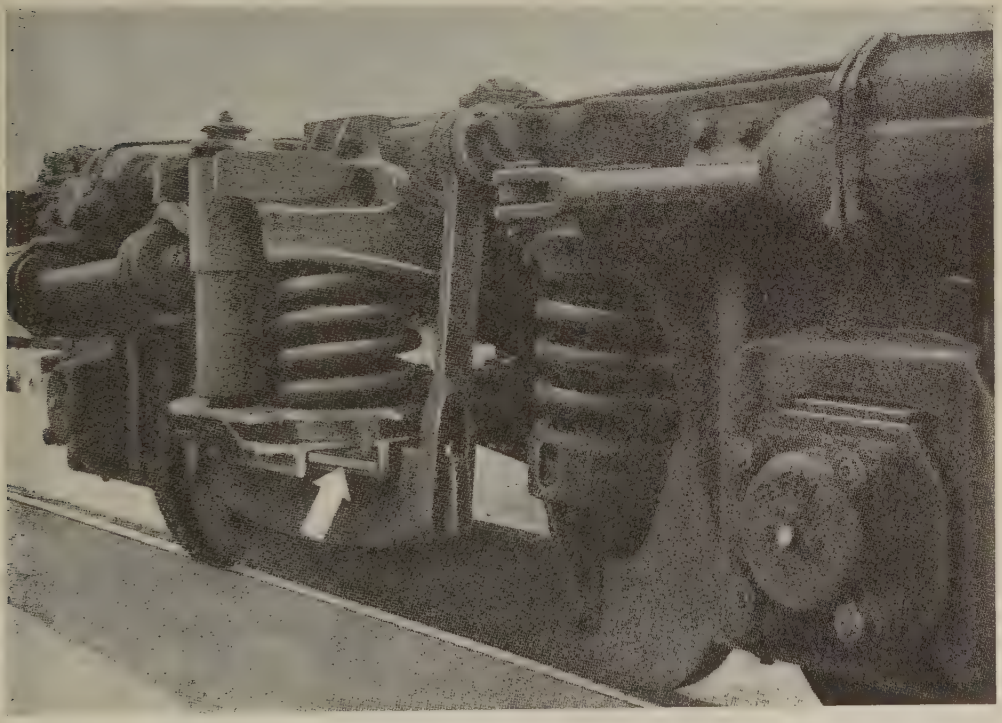
Resilient pads add to comfort on passenger cars,

by F. J. Carty, (*)

(Railway Mechanical and Electrical Engineer, October 1951).

There are approximately 40 000 passenger train cars in service on Class I railroads in the United States. During a period of one year, well over 555 million revenue passengers are transported in these cars. Of course, safety is of primary importance in the operation of railroads, but the importance of providing attractive comfortable, easy-riding cars is self-evident as this results in increased passenger revenue.

To attain this desirable condition, many factors must be given consideration, but



Spring-plank pads. On swing-motion trucks the bolster springs rest on the spring planks which run transversely underneath the bolsters and are suspended from the transoms by hangers passing under the spring planks. Spring-plank pads are applied between the top surfaces of the fillers and the bottom of the spring plank. The pads are held in position by downwardly projecting lips of the spring plank.

(*) Engineer, Fabreeka Products Company.

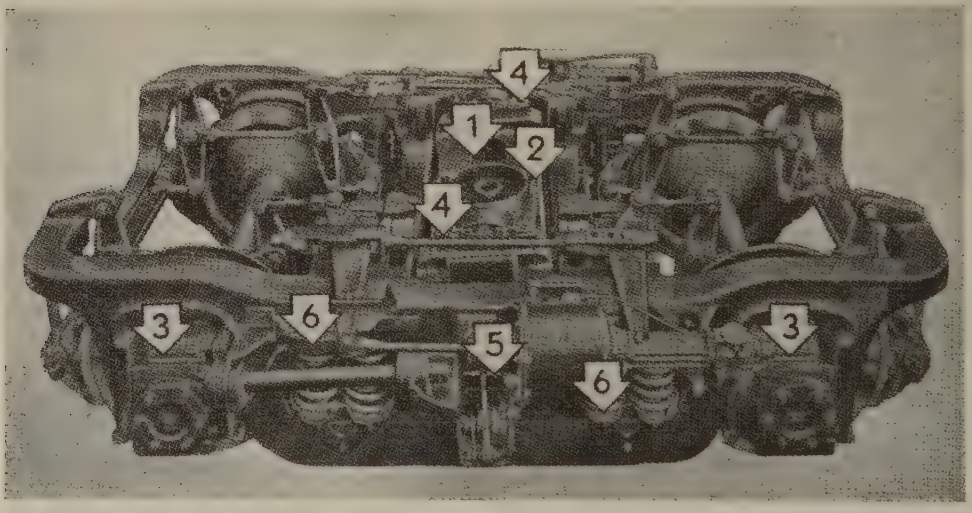
this article is limited to an outline of the proper utilization of resilient materials, in absorbing impact shocks, isolating high frequency vibration and abating noise on railroad passenger cars.

Modern passenger cars are designed to operate at speeds up to 100 m.p.h. and to traverse curves up to 18 deg. which are sometimes encountered in yards, although the maximum curvature of main line track seldom exceeds 6 deg.

then through the transoms to the spring planks, bolsters and center plates to the car body. The major part of the cushioning is accomplished by the springs, but as these are metal, high frequency vibrations are transmitted through them.

Lateral play necessary.

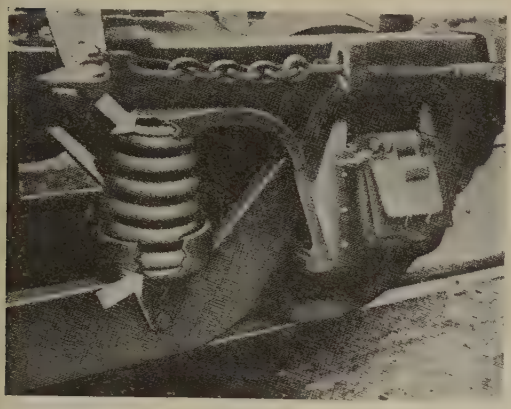
A limited amount of lateral play is necessary to prevent binding and to allow free-



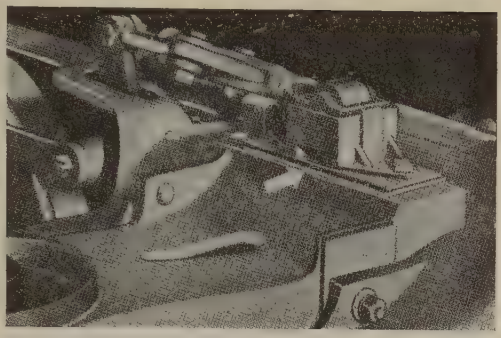
The six principal applications of resilient pads to new passenger car trucks are (1) top and bottom bolster coil springs; (2) center plate; (3) top of journal boxes; (4) under truck side bearings; (5) under spring planks; (6) top and bottom equalizer coil springs. To absorb impact shocks effectively, isolate vibration and reduce noise, the sum of the thicknesses of resilient pads installed at various points between the wheels and car body, should be at least 2 1/2 in. Older trucks can be modernized by substituting resilient pads in place of the wooden or metal shims commonly used to maintain the height of the couplers within permissible limits.

When a car is in motion, the rolling of the wheels on the rail generates vibrations and rumble, and the wheels passing over rail ends, crossing frogs and switches sustain impacts or sudden blows. Such impacts also set up vibrations which are transmitted through the wheels, axles, journals, equalizers and springs to the truck frame and

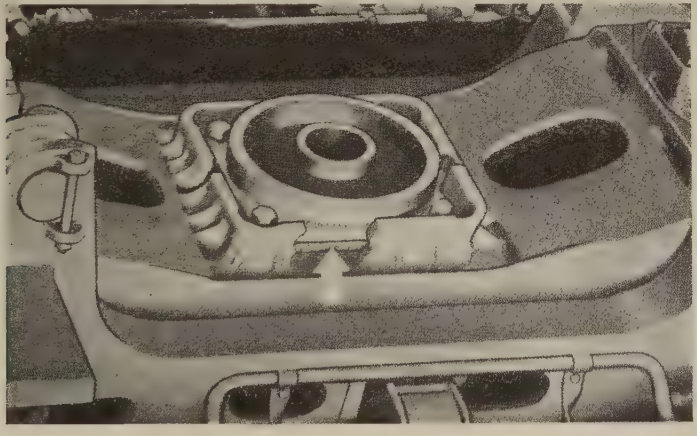
dom of movement of truck parts, especially when a car is going around a curve, and it may be pertinent to note that approximately 10 % of main line track is curved. On account of the relative movement of the car parts, certain lateral impacts of considerable magnitude occur and these may be considered as acting in horizontal



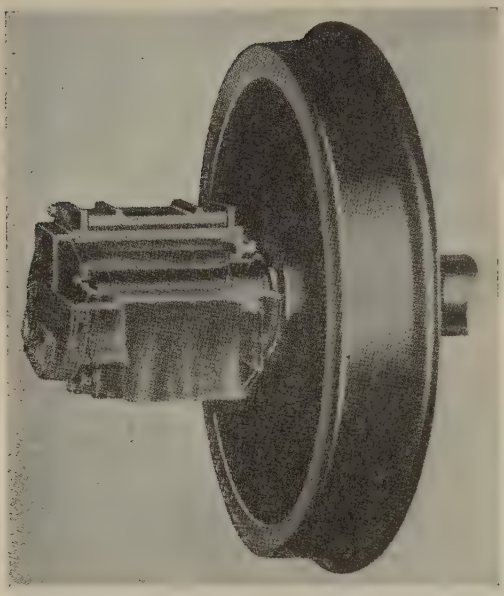
Equalizer and bolster coil-spring pads. Resilient pads are installed at the top and bottom of bolster and equalizer coil springs to reduce metal fatigue and spring breakage and to improve the riding quality of the car.



Side-bearing pads. Body side-bearing pads are attached to the body bolster on each side of the center plate to steady the car and prevent excessive rocking while the car is passing around a curve. The resilient pad is placed between the bottom of the side bearing and the top of the truck bolster. Truck side bearing pads are also used to cushion impact shocks, isolate high frequency vibrations and reduce noise.



Center-plate pads. It is the practice to design passenger-car truck parts for a center-plate load of 70 000 lb., which means that the pressure on center-plate pads is in the order of 300 or 400 lb. per sq. in. The efficiency of a resilient pad in the isolation of vibration varies directly in proportion to the thickness, but sufficient stability must be maintained. To obtain good service and long life from center-plate pads, they must not be subjected to abrasion; that is, the center plate in contact with the pad must not move horizontally with reference to the resilient pad.



Journal-box pads. Resilient pads applied to journal boxes break metal-to-metal contact, cushion ends of equalizers, isolate vibration, reduce noise and, in the case of roller type journal boxes, protect the rollers and races from damaging shocks.

planes. Other impacts, sometimes severe, occur in a fore and aft direction, when there is a sudden change in the speed of movement of the train, due to handling of the engine, application or release of the brakes or when cars are being coupled together.

Unless such shocks are cushioned and vibrations isolated, they frequently result in discomfort to passengers, loose bolts, fatigue of metal, breakage of parts and increased cost of maintenance.

Recognized principles of vibration isolation as related to the use of resilient pads, may be considered as depending upon two primary factors : (*a*) The frequency of vibration to be isolated, that is the forced vibration due to periodic and continuing disturbing forces; (*b*) The natural frequency of the system, or the rate at which it would tend to vibrate after sudden release from external force.

The frequency ratio is the ratio of the forcing frequency to the natural frequency. If the frequency ratio is less than 1.41, the resilient mounting is of no value in isolation of vibration, and may be harmful if resonance results, which is the case when the forcing frequency equals the natural frequency. For good vibration isolation, the frequency ratio should be at least two and one-half.

The elastic internal vibrations, which it is desired to isolate, and which are set-up in car parts as the result of impacts and by the rolling of the wheels on the rail may be assumed to have frequencies of over 100 cycles per second.

To absorb shocks, isolate vibrations and reduce noise, it is important to eliminate metal-to-metal contacts at certain points of the car body and trucks. Designers recognize that this can be accomplished successfully by interposing suitable resilient pads between the metal parts. Such resilient pads must be capable of dissipating energy in the form of heat and have mechanical resistance to vibration conductivity differing greatly from the metal parts.

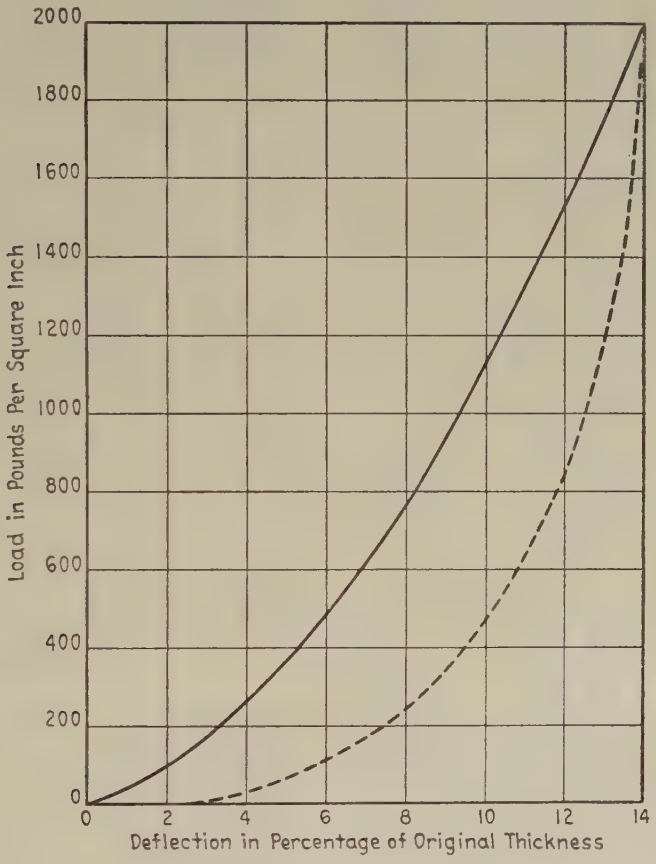
To give effective and satisfactory service, resilient pads must retain original physical characteristics during long service life and must not be damaged by millions of cycles of loading and unloading. They are required to withstand the action of water, brine, heat, cold and weather conditions generally encountered in railroad service.

Resilient pads store up energy like a spring and when pressure is released, give up this energy without appreciable loss. Their value as vibration insulators depends on this characteristic property.

The measure of resilience is in terms of the energy to produce a deformation and may be judged by the ratio of energy given up on recovery from deformation, to the energy required to produce the deformation.

Load-deflection characteristics should be studied when determining the most suitable and efficient resilient pads for use on railroad passenger cars, as the loading and unloading curves in compression, indicate the ability of a pad to absorb energy. The deflection which may be expected when the pad is under load, and is a criterion of its value as an isolator. The stiffness coefficient of a resilient pad increases with decrease in thickness.

The progressive reduction of amplitude



Load deflection curve. The solid line is the loading curve; the dotted line, the unloading curve.

deflection under load is one of the factors from which can be judged the effectiveness of the pad as a vibration isolator.

The stiffness coefficient and damping characteristics can be determined from the load-deflection curve. The stiffness of a resilient pad is indicative of the degree of

in free vibration is known as damping and in the case of rubber compounds considered as internal friction, which is inversely proportional to the frequency of vibration. Damping is a force which resists motion and the damping ratio is the ratio of any amplitude to the following ampli-

tude. Experience has shown that resilient pads having a damping coefficient of approximately 1.6 give very satisfactory service on railroad passenger cars.

The set of a resilient pad is the permanent change of form due to repeated or excessive stress, and creep is the additional deformation occurring with elapse of time while the pad is under stress.

To give satisfactory service, resilient pads must retain strength, resilience, and flexibility and must not have excessive set or creep under heavy loads, as this would decrease the natural frequency and might result in loose bolts and misalignment of parts.

Excessive noise is objectionable as it has a detrimental effect on the nervous system of passengers and every practical effort should be made to eliminate it.

When the frequency of vibration is less than 15 oscillations per second, the vibration is a shake or tremor. Between 15 and 30 oscillations per second, the tremor is accompanied by noises or clicks. Vibrations having frequencies greater than 30 oscillations per second are recognized as sound, the amplitude of vibration determining the loudness and the frequency determining the pitch.

Breaking the continuity of the path of sound by interposing resilient pads between metal parts which are being caused to vibrate, is effective in reducing noise. This is one of the more important functions of resilient pads on railroad passenger cars.

The load-deflection curve shown is typical of an efficient resilient pad having a durometer hardness of about 90, composed of layers of tightly twisted, closely woven, light weight cotton duck. Each layer is thoroughly impregnated with a special rubber compound and the layers are built up to required thickness and vulcanized together.

NEW BOOKS AND PUBLICATIONS.

[625 .28 (44)]

Locomotives des Chemins de fer français, à vapeur, électriques, Diesel-électriques et autorails. *(The locomotives of the French Railways, steam, electric, Diesel-electric and railcars.)* — No. 3, October 1951, Preface by Paul LEGREGEOIS, Divisional Inspector of the French Railways Steam Locomotive Drawing Office. — One album (6 × 9 1/2 in.) of 48 pages, diagrams and photographs. — 1951, Paris, Editions P. P. C., 39, boulevard Berthier (Price : 385 French francs.)

In spite of the relatively few number of types it contains, this Album No. 3 is of very great interest. There are several recent designs characteristic of French railway technique.

In the case of the steam locomotives, the first is a 4-6-4 for fast trains. Built in 1949, with a boiler pressure of 20 kg/cm² (284 lbs. per sq. in.) with an axle load of 23 000 kg (50 700 lbs.), it has raised the horse power to 3 400. The second, not quite so new, dating from 1940, is a 2-8-2 with an axle weight of only 18 t.

The four others are articulated locomotives, a compound four cylinder *Mallet*, a *Du Bousquet-De Glehn*, also compound with four cylinders, a *Beyer-Garratt* and a *Golwé*, both with four cylinders simple expansion.

In the case of electric traction, there are four locomotives, three of which are prototypes, a CC, a BBB and another CC. The latter, dating from 1950, is remarkable in that it was built to run on single phase current at a voltage of 20 000 and the industrial frequency of 50 periods. The object of this is to reduce the capital cost of electrification, and thereby reduce the limiting traffic justifying electrification.

In this series, the 2D2, not yet named, holds the record for power, 4 400 HP. In the case of speed, 160 km (100 miles/h), the CC comes first which using 1 500 V can haul a 530 t train at this speed.

The final item in this series is the rail motor coach with van compartment of the Ouest Region which is 600 HP and offers 78 seats with a total weight of 39 000 kg (86 000 lbs.). Its braking and acceleration qualities are such that it can run at high average speeds in spite of numerous intermediate stops.

The two Diesel locomotives are also recent types, and both intended for shunting operations. Although included with the first under the heading Diesel-electric, the second has mechanical drive with hydraulic clutch which costs considerably less.

The four railcars with Diesel engines, made by various firms, come into the medium power class. The power ranges between 300 and 90 HP, the speed between 110 and 60 km (68 and 37 miles/h), and the number of seats between 67 and 34. The latter figure relates to the *Bernard* railcar which has the same characteristics as an ordinary motor coach apart from the wheels. Two vehicles of this type are fitted with a device which enables them to turn through 180° at the terminal stations.

This little collection is truly representative of the evolution of the technique of traction in the last dozen years. At the beginning of the album, there is an explanatory diagram of oil firing, another recent introduction on the European continent.

E. M.

[**31** (3)]

Statistical Yearbook 1951. — Third Year. — Published by the Statistics Office of the United Nations Organization, Department of Economic Questions. — One volume (9 × 11 1/2 in.) of 616 pages, with many tables. — 1951, New York, Published by the O. N. U.

This third issue of the Statistical Yearbook of the United Nations is similar to the two previous issues. It is marked however by certain additions which increase the documentary value of this publication the importance of which we have already stressed (see *Bulletin* of July 1952).

Amongst the new data included, mention must be made in the first place of a chapter relating to consumption under ten headings. The term consumption is taken in a very wide sense covering foodstuffs, the main sources of power, various industrial products and the three main groups of fertilisers. The two tables relating to the availability of foodstuffs are based on the foodstuffs balance sheets prepared by the F. A. O. (Food and Agriculture Organization), the department of the United Nations dealing with food and agriculture.

Many of the tables already included in the former issues have been considerably extended. For example, in the chapter devoted to public finances, in the various national accounts posts of economic importance have been included and the operations of the central government banks are the subject of a separate table.

In the case of transport, as we have already said, the statistics cover the railways, road services, maritime transport and civil aviation, for most of the years from 1931 to 1950. There are interesting variations to be noted. Side by side with those transports, which have not recorded any great progress in recent years, are others which have developed continuously.

In view of the extraordinary scope of the work, which covers nearly all branches of human activity, the information supplied may be called complementary. For those readers who wish to obtain more detailed analyses, there is an appendix giving a list of the chief series of statistics published by various bodies, and the United Nations in particular.

E. M.

[**385** (05 (43)]

ETR, Eisenbahntechnische Rundschau *(Technical Railway Review)*. New Monthly Review. Published by Carl Röhrig Verlag, Darmstadt, (Size : 8 1/4 × 11 3/4 in.). — Printed on special paper. — At least 32 pages of text. — (Price per number : D. M. 4.50; Subscription 3 months : D. M. 12.00).

This new review, the first issue of which is in our hands, that of January 1952, is intended, according to an editorial note, to supply a want in technical, industrial and railway circles. Its appointed object is to give by means of substantial notes as complete a report as possible of technical questions now to the fore in the railway field. The responsibility for preparing these notes will fall upon a Committee composed of important officials of the Reichsbahn and training centres, with Dr.-Eng. A. BAUMANN of Karlsruhe as the chief editor.

The German Railways are faced with an important work of reconstruction and modernization and the problems arising

are manifold. The promotors of this new publication hope that it will contribute to the restoration of the railway by collating ideas, theories and the results of experience.

According to the editorial note, those responsible for the articles wish to keep this review on a high scientific plane. Judging by the contents of this first issue, they have succeeded in their objective.

A work of this kind is likely to be of interest outside Germany. To facilitate its diffusion, it is proposed to give a summary in English and French at the end of each article.

The review will be completed by a quarterly supplement called « Archiv für Eisenbahntechnik » (Railway technical archives), reserved for articles of some particular technical scope. Special issues will cover important questions.

With such a programme and in view of the circumstances in which it has made its appearance, it is permissible to surmise that the new review E. T. R. will have the success which the Governmental Authorities and General Manager of the German Federal Railways wish it in the prefaces to this first issue.

E. M.

[**624** (460)]

MENDIZABAL Y FERNANDEZ (D.), Road Engineer, Assistant Manager of the Spanish National Railways, — **Datos utilizables para el posible estudio de una nueva instruccion para el calculo de tramos metalicos.** *(Data to serve as a basis for the study of a new instruction on the calculation of metal bridges.)* — One brochure (8 1/4 × 10 3/4 in.) of 126 pages with tables and figures. — 1952, Madrid, published by the Railway Study and Research Laboratory of the Roads, Harbours, and Canals Engineering School.

The instruction now in force dates from 1925. Since that date operating conditions have been considerably modified, both as regards the speed of the trains and the weight of the traction and transport stock. The proposition of the Railway Study and Research Laboratory to investigate a new instruction having been approved, the work was entrusted to one of the members of the Council, Dr. Domingo Mendizabal, who took a considerable part in the preparation of the present instruction. The results of his investigations are given in the present publication.

The basis of the study was a wide scale enquiry into the operating conditions in a great many countries and the essential clauses of the regulations in force. These were the subject of a detailed examination during which they were compared with the Spanish regulations. Taking into account all the various considerations likely to affect the measures to be taken, the author was able to formulate well-founded conclusions.

The report covers railway bridges, both standard and narrov gauge, and road bridges. In the case of the former, a special examination of the question of impact was made. Here great diversity was found not only in the formulæ but also in the coefficients used. The author indicates that it is necessary to take into account, in addition to the span, various factors, such as the condition of the track and the method by which it is carried on the bridge, the kind of traction, and the speed of the trains, and he suggests a new formula whilst awaiting the results of the researches he considers it is desirable to undertake.

In the third part of the book, it is question of the stresses resulting on the one

hand from outside sources, wind and variations in temperature, and on the other, those due to the rolling stock itself: centrifugal force, lateral stresses, braking and starting.

The fourth part covers a discussion of the regulations relating to the calculation of the supporting gear, the importance and measurement of the deflections, the effects of alternating stresses, the calculation of parts liable to warp, trials, minimum thicknesses. It ends by a complete enumeration of the modifications suggested to the present regulations, together with numerical tables and the necessary drawings.

This work, apart from the object indicated, the utility of which is obvious, is of great interest to all specialists of bridges owing to the comparative study of the regulations applied nearly all over the world.

E. M.

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